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The Reconstruction of the old Chain Bridge at Newburyport, Mass.

By Edward C. Sherman*

It is seldom that a bridge of any considerable size, carrying the traffic of a populous region, has a useful life of a full century, and it was not strange therefore that when the so called Chain Bridge over the Merrimac River at Newburyport, Mass., was declared unsafe and plans for a new structure were discussed, there was a strong popular demand for the retention of all its distinctive features, including the wooden towers and the iron suspension chains.

Specifications for a new bridge were accordingly prepared, providing for steel towers to be inclosed in a restored wooden framework with sheathing and shingles essentially like the wooden towers of the old structure. It would appear, however, that the County Commissioners or their engineer realized the fickleness of popular opinion, for alternate specifications were prepared at the same time calling for building the entire towers of reinforced concrete, although in this case, too, the general form of the ancient wooden ones was to be retained, except that the two arched openings which show so well in the photograph (Fig. 1) were to be merged into one, adapted to the single roadway which was to replace the double ones.

In both specifications provision was made for rehanging the old chains, although they were to be merely ornamental as they were to be adjusted so as to carry little or no load.

The old Chain Bridge was fully described by Prof. A. P. Mills in Engineering News, Aug. 3, 1911, p. 129, in an article on the physical and chemical tests which were made upon some of the links from the old chains. It appears desirable, nevertheless, to repeat the following quotations from the Newburyport *Herald* of Dec. 14, 1810:

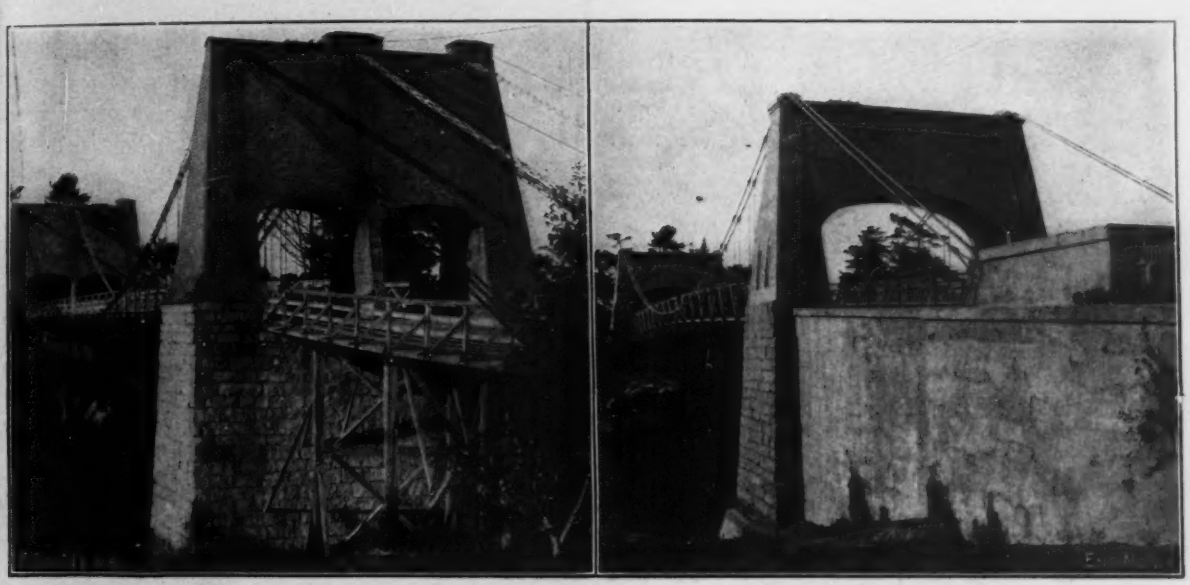

Fig. 1. The Old Bridge Built in 1810 Fig. 2. The New Bridge Built in 1913

Figs. 1-2. The Chain Bridge at Newburyport, Mass.

The chain bridge recently thrown over the Merrimac, three miles from this town, is now open for the accommodation of travelers. It consists of a single arch of 240-ft. span and 40 ft. at its greatest elevation above the water. The abutments are constructed entirely of rough and split stone, the whole quantity being 4000 tons. On the abutments at each side of the river, framed piers are erected and capped with stout timbers to support the chains from which the flooring of the bridge is suspended. The whole quantity of iron used in chains, etc., is 22 tons. The whole flooring admits two passages 15 ft. wide, rises 3 ft. in the center, is firmly connected and strengthened by stout railings and has a very light and agreeable appearance. The principle upon which this work was constructed was invented by James Finley and patented by him in 1808.

The history of the old bridge is rich in romance and tradition, for Newburyport, at the time of its construction, was a great trading and privateering port and the surrounding country was peopled with daring seamen. Whittier lived and wrote in Amesbury, the town on the northern end of this bridge, and the home of Harriet Prescott Spofford was near by. L. W. Moore, the notori-

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ous bank robber, tells in his autobiography, of hiding the loot from the Northampton Bank, amounting to $700,000, in one of its hollow piers.

By the time that construction was to begin on the new structure, the public demand for the reproduction of the distinctive wooden towers and for the retention of

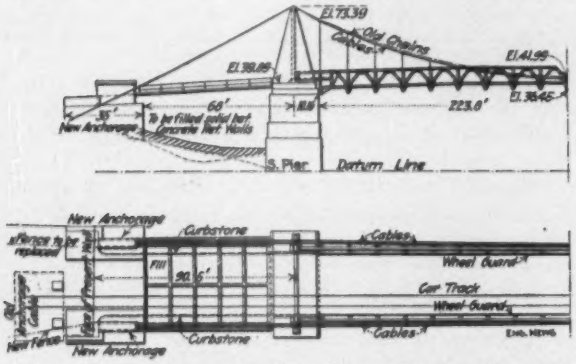

FIG. 3. DETAILS OF THE NEW NEWBURYPORT BRIDGE

the iron chains had subsided so far that it was found possible to proceed under the alternate specifications with the construction of a modern bridge. It was built in accordance with the general plan (Fig. 3), except that the old chains were entirely omitted.

The contract plans called for a new south approach, to replace the timber trestle (Fig. 1), to be made of reinforced concrete in cellular form with 12-in. walls. Further consideration of the probable effect of tidewater upon these thin walls led to the substitution of massive concrete walls of gravity section, made of 1:3:6 concrete and faced with 6 in. of 1:2:4 concrete. Their design and construction offered no difficulties, as they rest on ledge rock and their bases are above the low-water line.

The ledge at this end of the bridge occurs at only a few feet below the surface of the ground so that the cable anchorages were likewise built directly upon it. At the north end ledge rock was not encountered and a stepped form of anchorage was adopted.

The new reinforced-concrete towers which support the saddles for the cables, have somewhat the form of the old wooden towers. They were built directly upon the old stone piers and are hollow, access to the interiors being by doorways in the ends (Fig. 5).

The cables are made up of a large number of small wires, about 1/8-in. in diameter, laid parallel to each other and wrapped, enough wires being used to make up a total area of 12 in. of metal in each pair of cables. The wire was required to have an ultimate strength of not less than 200,000 lb. per sq.in., an elongation of not less than

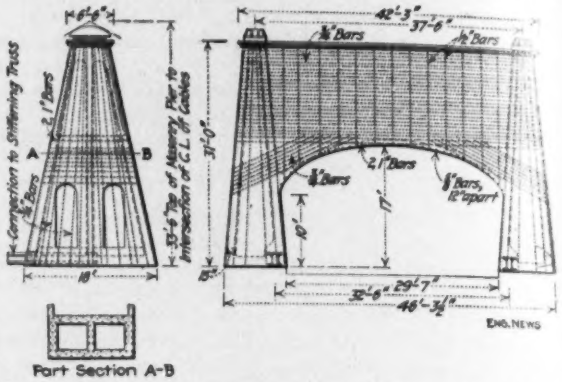

FIG. 5. DETAILS OF REINFORCED-CONCRETE TOWER OF NEWBURYPORT BRIDGE

2½% in a length of 5 ft. and of not less than 5% in a length of 8 in.

It was required that in making the cables, any wires which had to be spliced should be joined so as to develop at least 95% of the strength of the wire.

In order that each pair of cables might be of exactly the same length and that no adjustments might be necessary, they were made on the ground by winding the wires back and forth around two heavy concrete posts, set in the ground at a distance apart exactly equal to the total distance between the anchorage pins. When enough strands of wire had been laid down to provide the required area of steel, sufficient "cable-shield" was applied to fill all the interstices between them and the whole cable was wrapped with soft-iron wire, wound on by machine. The cables were painted after erection.

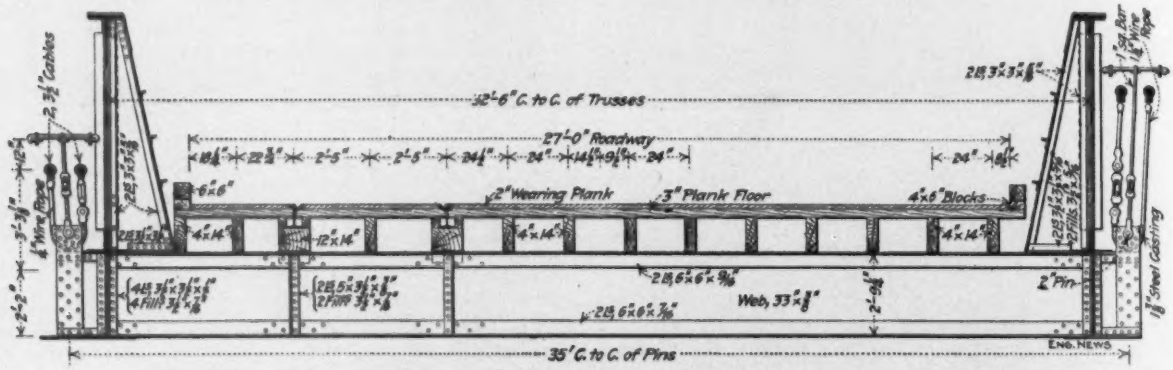

FIG. 4. SECTION THROUGH ROADWAY

The method of attaching the wire-rope suspenders to the ends of the floor beams is clearly illustrated in Fig. 4, which shows a cross-section of the floor system of the bridge. The stiffening trusses, to which the floor beams are riveted are pin-connected at the middle of the span.

The new bridge was built by the Holbrook, Cabot and Rollins Corporation, as contractors, under the direction of the County Commissioners of Essex County. Robert R. Evans had direct charge of the work as County Engineer, and Prof. George F. Swain, of Harvard University,

was consulting engineer. Fig. 2 is a view of the new bridge taken from practically the same point as that of the old in Fig. 1. The duplication of effect is marked.

Causes of Wear and Deterioration of Roadways *

BY LAURENCE J. HEWES†

At the present time in the United States there exists no standardized method for measuring either the wear or deterioration of our highways. In fact, traffic, which is the fundamental phenomenon in the highway domain, still lacks a standardized unit of measurement.

It is quite possible that at the present time the taking of state-wide traffic censuses is not economically justified, but it must be admitted that any deductions as to the wear of roads are necessarily unsound unless they are made with due regard to the service of the road.

MACADAM ROADS

With reference to the wear of water-bound macadam roads, reliable statistics are on record in the reports of the Massachusetts Highway Commission. These reports show the behavior of 55 separate sections of macadam road during an interval of six years ending in 1907. Since the year 1907, published information has been almost totally lacking. The method of measurement of annual wear reported for Massachusetts is indirect. The roads in question were allowed to wear until they required general resurfacing. The amount of stone required for resurfacing is accurately recorded in short tons. The dates of original construction and of resurfacing fixed the interval of wear. The square yards resurfaced are accurately known. It is then possible to deduce an annual coefficient of wear in tons per square yard. Such a coefficient accurately computed from the behavior of the 55 roads in question is approximately 0.023 ton per sq.yd. per year. The corresponding traffic upon these roads during this interval is not known. The closest index of the traffic is obtained from the traffic census taken throughout the state during the months of August and October in 1909 at 237 stations. The daily traffic in August was 83 light vehicles and 76 heavy vehicles; in October, 69 light vehicles and 75 heavy vehicles, with an automobile traffic of 115 and 77 in the respective months. What we are able to derive from the records of Massachusetts checked by similar figures in New York State and elsewhere, is the fact that water-bound macadam roads wore out after an interval of between six and seven years so that they required resurfacing. The Massachusetts roads, whose records must be given due weight, were largely surfaced with trap rock.

Observations during the past few years apparently justify a conclusion that much importance attaches to the proper placing and rolling of broken stone in a macadam roadway. It may be observed in many places in New England that water-bound macadam roads have successfully withstood the traction of automobile traffic for a number of years. In almost every instance these roads have been laid down by men of exceptional skill and experience. It appears to be true that the older macadam roads well seasoned or cured did not suffer under automobile traffic as did the newer built sections. It is quite plain, therefore, that water-bound macadam construction must secure, if possible the effect of curing at the time the courses are put in place.

An important fact that has presented itself in the past five years in regard to water-bound macadam roads is the difficulty in making repairs and in proper maintenance without converting the water-bound macadam road into a bituminous-bound surface. It cannot be denied that with a great shearing force along the surface, the old-fashioned patch is a thing of the past. Either water-bound macadam roads must be surfaced and treated with some bituminous material, or they must be allowed to wear until complete resurfacing is justified. To the volume of traffic, however, as well as to the nature of the traffic, must be attributed the increased wear of water-bound macadam roadways.

CONCRETE ROADS

The most striking observation concerning the wear and deterioration of concrete roads is that such roads have apparently so successfully resisted wear and deterioration that they are now freely built throughout the country. It does not appear that one of the hypothetical objections to concrete roads, namely, the injurious effect upon horses' feet, is urged to any extent by the users of the road. There is, however, a prejudice against the noise of hoofs on concrete in larger towns and the surface is often slippery. There are few observations concerning concrete roads which may be considered valid for all such roads. Perhaps the most nearly universal characteristic of wear and deterioration is the tendency to crack.

The principal objection to the cracking of the roads is because the cracks act as points of wear. Extensive cracking is also unsightly in cities. The tendency to crack has been combated with considerable success by the use of expansion joints (or more correctly contraction joints), at distances varying from 20 to 100 ft. Unfortunately, the contraction joints become points of wear, as may be observed on the older sections where worn joints have been repaired with bituminous material. The wear apparently is due to the abrasion caused by iron-shod traffic. Metal-protected joints placed with fins let into the roadbed during construction have been used with success in Michigan. It is probable that exact measurements on concrete roads four or five years old would show uniform wear, but in many cases except at joints and cracks such wear is not visible in any ordinary inspection. There have been, however, some important exceptions where the construction was inferior.

There is, apparently, no damage caused by the action of rubber-tired motor vehicles. As far as has been observed, the greatest deterioration of concrete roads is caused by defective construction. On a concrete road in Ada County, Idaho, are bad ruts beginning to show after one year throughout at least 50% of the length of the road. These ruts are plainly caused—at least in part—by the presence of excessively large stones in the gravel aggregate used in construction of the wearing surface.

The concrete approaches to the Potomac River Bridge at Washington, D. C., have caused a great deal of trouble, owing apparently to cracking of the roadbed, due to settlement of the fill. The method of repair has consisted in removing by hand labor with drills the entire depth of concrete in patches. The cavities are then carefully replaced and the surface brought flush with the surrounding roadway. The expense of this operation, under ordinary circumstances, would be prohibitive.

The extreme difficulty in making repairs on the concrete roadway itself justifies, therefore, most careful methods in construction and warrants the use of a concrete mixture of known behavior. There is reason to believe that where the concrete road has been protected with a moist covering for ten days or more while setting, the tendency to crack has been diminished and the quality of concrete much improved.

The use of thin coats of bituminous material and fines on the concrete roadways is as yet in an experimental state. Apparently thin coats of favorably prepared tar adhere longer than do some of the asphaltic preparations. Under heavy traffic, particularly iron-shod traffic, paint coats of bituminous material on concrete have been observed to peel quickly and extensively, especially in cold weather. The use of this particular method of surface construction has, however, been of too short duration to warrant final conclusions as to its suitability at this time, but it apparently cannot last more than two seasons. It seems quite probable from present indications that bituminous-wearing coats are desirable but accurate determinations of the economical thickness is still lacking.

BITUMINOUS-BOUND MACADAM ROADS

Under this heading we must include all forms of broken stone road construction in which a bituminous-binding material is used in any way. The most definite lesson is in regard to the cost of annual maintenance. There are sufficient statistics to warrant assumption of a probable square yard cost for maintenance per year at from four to eight cents. If we can assume that this charge supplies absolute maintenance, that is to say, if we can consider the life of the road as indefinitely prolonged, the ultimate cost of highways, in view of the increase in traffic, has not been much increased by the change in construction since 1906. It was very easy to overlook the cost of general resurfacing of water-bound macadam roads in figuring annual maintenance charges. If the resurfacing operation at intervals of 6.5 years had been made an annual charge against the old water-bound macadam roads, the total annual cost of upkeep would have been not far from 5c. per sq.yd. per year. Of course, at present we cannot say that bituminous macadam roads will not in time require considerable resurfacing, even though such roads were originally perfect, but the period before resurfacing will doubtless be longer than the former life of the water-bound road.

*From a paper presented before the Permanent International Association of Road Congresses, London, June, 1913.

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Some of the common methods of wear and deterioration are bleeding, crumbling in patches, pitting of the surface—which allows water to collect, the formation of broad shallow ruts and general raveling of the skin or road "enamel."

Although it is true that bleeding on the bituminous-bound concrete road may take place at a considerable interval after the road is finished, it is usually a defect of construction rather than a phenomenon of wear. It is generally understood that automobile traffic on a green bituminous road tends to bring up bituminous materials. The general treatment of excess of bituminous material on a road surface has been to apply fines as a blotter. In some instances there results a weak crust which tends to develop planes of cleavage, particularly in the early spring following the treatment.

Crumbling in patches has been observed. This form of deterioration is apparently likely to present itself where the broken stone near the surface is large and with its voids imperfectly filled. Crumbling may occur for many other causes, among which have been observed the lack of sufficient binder, nonuniform stone and insufficient rolling.

Pitting of the road surface will occur in bituminous construction. Just as much care is needed on the subgrade and in the method of dumping and spreading stone and in rolling the same as was formerly used in a first-class water-bound construction. Pitting may be a worse defect on bituminous roads because it affords an opportunity for water and ice action on a positive binder.

Cases of general ravel of the superficial layer of bituminous-bound roads are becoming infrequent. They are manifestations of defect of construction, or of continued neglect in most instances. It is quite generally evident that bituminous-bound roads in the northern latitudes of the United States undergo a continuous though slow deterioration from year to year, in some prarie sections the soil tracked on the roads appear to emulsify bituminous material. A most common form of deterioration appears to be a tendency for a bituminous binder to become lifeless or "short," and for flaking to take place.

BRICK ROADS

There are probably few cases on record in America where brick roads have actually worn out. Brick roads deteriorate but, in most instances, by the chipping of the bricks and the formation of spots and holes under the action of iron-shod traffic. With the use of a cement grout filler and the selection of better brick, the chipping of brick pavements and the formation of holes has decreased. It is becoming more common to use a solid concrete foundation course for brick pavements and this practice has almost entirely done away with defects in the foundation. Perhaps in no other form of road construction has more refinement in method developed during the past five years than in vitrified brick-paving construction.

From the standpoint of wear and deterioration, well laid brick pavement appears to rank with concrete and it may possibly be more enduring and less dusty. Where street car tracks are present, it has been found that brick pavements sometimes crack parallel and adjacent to the track. Such cracking can be avoided if the rails are left free to depress under the action of the passing car. It is also possible to make the construction of the track sufficiently massive to avoid cracks due to depression. Immediately after construction, transverse cracks have sometimes been observed, particularly where there is a wide range of temperature. All cracks become points of wears and may cause chipping, also newly grouted brick roads have been observed to chip if traffic was allowed on them too quickly. There is every reason to believe that cement-grouted brick pavement will better withstand wear and deterioration if it is kept covered and moist until the mortar has had time to thoroughly set, say for a week or ten days.

Some valuable observations upon the behavior of brick pavements are recorded by James E. Howard, of the U. S. Bureau of Standards.‡ Mr. Howard's measurements show that a progressive change in length of the pavement is due to alternate changes of temperature and that open cracks become partly filled with abraded material and are prevented from closing with the rise in temperature. It is desirable to avoid a wide range of temperature on newly constructed brick pavements. Moreover, it appears that a certain amount of compressive stress in a longitudinal direction is beneficial because transverse cracks are kept closed. Numerous cases are reported where brick roads have deteriorated because of the lifting of the brick road at transverse joints when the road expands longitudinally with a rise of temperature. Improved results have followed the entire omission of transverse expansion joints. Under ordinary longitudinal compression with increase of temperature, spalling does not occur.

The cost of maintenance of well laid brick pavements, as far as it has been made a matter of record, is remarkably low. There are many brick roads in America constructed in the decade beginning with 1891 which are still serviceable and some of them in very good condition. It is not apparent that frost or snow does any damage to a brick road, certainly rubber-tired vehicles cause no measurable wear and the effect of sun or variation of temperature can be largely minimized by proper construction. There is a tendency for all brick roads to creep outward on curves, due to the expansion with heat.

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Chinese Famine and Proposed Flood Prevention*

By Charles Davis Jameson†

Hundreds of thousands of dollars have been poured into China for famine-relief work. Large sums have been contributed by the Chinese government. In 1911 the American Red Cross organization and the U. S. Department of State decided to have an engineering examination made of the great flood and famine region with a view to formulating preventive measures. In the report here abstracted Mr. Jameson gives the results of preliminary studies of the causes of the floods and the means for their prevention.

In those portions of Anhui and Kiangsu which lie north of the Huai River, the Hungtze Lake and the old bed of the Yellow River, south of the Province of Shantung and the present bed of the Yellow River, and extending east and west from the sea to the Ke River, is a section of country which has known but little rest from floods and subsequent famines for the last 2500 years.

This section is a portion of China's great alluvial plain, extending from the mountains on the West to the sea, and from Shan-hai-kwan to Hanchow. All of this plain is in process of building; no part is finished, but the least finished portion is that mentioned above, and the changes which are going on in this section form one of the most interesting examples of continent building at present in existence.

What adds to the interest of Nature's work going on here is the fact that we have the history of this section—physical, geographical and human—for the last twenty-five centuries at least. Authentic records show the changes in the river channels, the swinging north and south of the Yellow River, which during that time has passed into the sea at various points between Shanghai and Tientsin, also that one time—some twenty centuries ago—much of the water of the Yangtsze went into the sea at Hanchow, while another portion flowed north into the Huai River and thence to the sea, down the now called old bed of the Yellow River, ten centuries before the Yellow River made its last visit south.

In addition, the records of the various cities and districts give the years of flood and famine and the amount and kind of relief given to the sufferers; taxes remitted year after year, millions of ounces of silver and tons of free grain. The records also show more or less the work done to prevent the floods, or at least many of their evil effects, and in these records of the work the most noticeable fact is, that while enormous sums were appropriated for the building of dams, dikes and embankments to hold and confine the water and to safeguard certain restricted areas, comparatively little or nothing was done to deepen channels or furnish means for the free and quick passage of the water to the sea. The lower reaches of the rivers were allowed to silt up until there was no adequate outlet, the embankments were raised, the unprotected areas were flooded, and eventually the em-

*Condensation of a preliminary report on "River, Lake and Land Conservancy in portions of the Provinces of Anhui and Kiangsu, North of the Yangtsze River," dated July, 1912.

†American Red Cross Engineer to China, Peking, China.

‡"Engineering News," June 20, 1912, p. 1173.

banks were broken, and floods and death and famine followed, and with this came immense appropriations for the repair of these embankments, until one can almost believe the truth of the old Chinese saying regarding the conditions which have obtained for centuries on the Yellow River, "how would we get paid for catching the tiger if he never escaped?" In modern works of this description the object is not only not to catch and confine this tiger, but to allow him to escape by a well prepared and most obvious road as quickly as possible.

During the last ten or twenty years the frightful suffering due to these floods has been brought to the notice of western nations through the foreign missionaries, and year after year hundreds of thousands or even millions of dollars have been poured into China for the relief of the sufferers, three-quarters from the United States and most of the remainder from Canada. Year after year this money from outside has gone to feed China's starving millions, and much of China's money has gone the same way, but in all these years China has not made one singlie effort to have the cause of these almost annually recurring floods investigated, and to ascertain whether it were not possible to lower the flood level and thus do away with the cause of the famines.

The floods have so increased in frequency and the famines in acuteness that now, over the whole area under consideration, the farmers do not average more than two crops in five years, where, if the floods were eliminated, the normal condition would be two large crops each year, and this loss is an ever increasing one. There is but small chance for the people to recuperate. Year after year they plant and the crops are lost. Then there comes a year when there is no seed to plant, then no animals with which to plough, then no ploughs or other farm implements; the house furniture follows, sold for food or used for fuel; then two families move into one hut, and the extra hut goes for fuel with which to boil weeds and the bark of trees; this gone the people steal, murder, beg, and often resort to cannibalism, and thus one of the richest agricultural sections in China is in such a condition that even robbers are becoming discouraged. No work of any kind is done to improve the rivers, the upper reaches are grown up with reeds, and plants, and the water cannot get away but spreads over the land, making swamps where once were rich fields.

During the summer of 1911 the National Committee of the American Red Cross and the Department of State decided that an engineer should be sent to China to make a thorough examination of this flood and famine region, with a view to designing some scheme by means of which the flood level could be lowered, the rivers properly trained, and the swamps and shallow lakes drained and made available for agriculture. Through the American Legation in Peking this offer was conveyed to the Chinese Government, which accepted it with much pleasure, stating that it would furnish all the assistance the American Engineer might need in the way of survey parties, etc., and would also pay the field expenses of such parties and the expenses of the American Engineer from the time of the arrival in China until his preliminary examination and work were completed, the National American Red Cross paying the salary of the engineer sent. I had the honor to be appointed by the National Committee of the American Red Cross with the approval of the Department of State for this work, and arrived in Peking on July 16, 1911.

The area to be studied covers approximately 100,000 sq.mi. (See map, Fig. 1). It contains portions of four provinces, Shantung, Honan, Anhui and Kiangsu, and lies between the Yangtsze River on the south and the Yellow River on the north, and within it is the Flood and Famine Region on North Anhui and North Kiangsu.

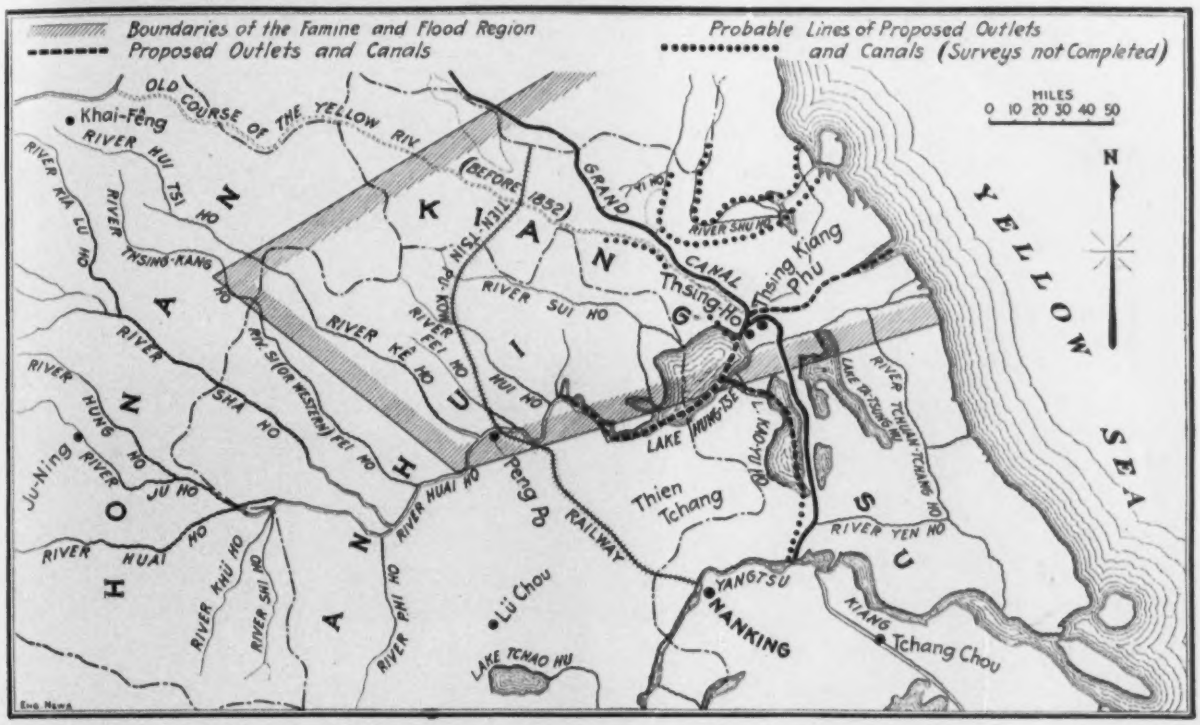


FIG. 1. MAP OF THE FLOOD AND FAMINE REGION OF CHINA

CLIMATE—The climate is of a mild and temperate character, the thermometer ranging from a maximum of 100° F. to a minimum of 20° F. The winter is short; the ground freezes to a depth of from 2 to 3 in., and none of the rivers or lakes become covered with ice.

The soil is a light alluvial and of great richness, with the exception of some fifteen miles along the sea coast, where the elevation is not as yet sufficient to free it from salt.

RAINFALL—The rainy season is during June, July and August. Some rains occur during April and are of much benefit to the crops. The rainfall is ample, and when the rivers have been properly cleaned and regulated and provided with outlets, all ordinary floods will be eliminated.

It is impossible to ascertain the average number of inches per normal year, as no records have been kept, but the Chinese records show that years of drought are almost unknown.

In June, 1910, there was a local downpour in the region of Sze-chow, lasting some 42 hours, during which it was estimated by the Divisional Engineer of the Tientsin-Pukow Ry. that 24 in. of water fell.

AGRICULTURE AND INDUSTRIES—This entire area is strictly one of agriculture. There are no industries of more than local importance, and the existence of these is due entirely to the lack of means of transport.

The most important staple agricultural products of North Anhui and North Kiangsu are wheat, oil bean and tall millet. There is an abundance of good fruit in season, cherries, apricots, peaches, pears, grapes, small melons and water melons.

RIVERS AND LAKES OF THE FLOOD REGION—The main river systems of the flood region are three, viz., the Shu River, the Yi River and the Huai River.

The Hungtze Lake, which is merely the backwater of the Huai River, due to its lack of suitable outlet, has an approximate area of 450 sq.mi. The greater portion is less than 4 (?) ft. in depth at normal low water, the deepest part being along the southern shore, the old channel of the Huai River when it had free access to the sea, before 1300 A.D.

The Shu and Yi Rivers are distinctly torrential in character. Rising in the deforested mountains of Shantung, a section subject to heavy rains, the upper reaches of these rivers have a steep fall, and the lower reaches, after passing into the alluvial plain, a fall of but a few inches to the mile. In the case of the Shu its course to sea is long and winding through this alluvial plain, a distance of 85 miles. The last twenty miles near Haichow are much silted up, and the consequence is that after a heavy rainfall in the deforested mountains, where there is nothing to absorb the water, it rushes down the steep incline of the upper reaches in a torrent, and upon reaching the flat country with the channel more or less silted up and in no way equal to the rapid carrying off of the large amount of water forced into it, the banks are overflowed and the country flooded, until it becomes one vast shallow lake. Eventually the water passes to the sea by innumerable and unsurveyed canals and creeks.

The whole section of Kiangsu north of the old bed of the Yellow River and east of the Grand Canal is one vast network of canals and small rivers, with their beds so little below the level of the surrounding country that only comparatively moderate rains are necessary to create floods.

The Yi River, as before mentioned, discharges into the Grand Canal. During the dry season both this river and the Shu discharge but little water and are in no sense navigable, but after rain this Yi River becomes a torrent which pours into the Canal, tearing away the western dyke (if it has been repaired since the previous floods), and flooding the country on both sides of the Canal. During the rainy season the river often rises 10 or 15 ft. in 12 hours, and sweeps all before it.

The Huai River and all its tributaries as far east and including the Ke River have well defined channels, and these channels are for the most part of sufficient capacity to handle ordinary floods.

THE MING DIKE—This dike is some 25 ft. in height, 300 ft. wide at the base, and some 150 ft. wide at the top. It was first built during the early part of the Ming dynasty (1468) and of earth only. Although destroyed in parts by extraordinary floods, it was kept in comparatively good condition until large sections were swept away either just before or just after the commencement of the Ching-dynasty. The second emperor of the Ching dynasty, Kang-he (1662-1723) not only thoroughly rebuilt and repaired it, but added to its resistance to floods by facing the entire water side to a height of 12 ft. with fine ashlar masonry laid in impure lime mortar almost equal to natural cement, each course being about 16 in. in thickness, alternating headers and stretchers. The monumental work is in good condition today, and is a striking example of what the emperors of China once did for the good of the people and the country.

This dyke was built to protect the Grand Canal between Thsing Kiang-pu and the Yangtsze River (133 miles) from the floods of the Yellow and Huai rivers, and thus save from absolute destruction the whole section of rich and densely populated rice country east of the Grand Canal and south of the old bed of the Yellow River, known as the Hia (Low) country.

THE GRAND CANAL—One of the most important features, both from a topographical and hydrographical standpoint in any study of the river systems of North Anhui and North Kiangsu is the Grand Canal. As shown by the map (Fig. 1) this canal leaves the north bank of the Yangtsze opposite the city of Chinkiang, and runs for a distance of 133 miles north to Thsing Kiang-pu. Just north of this place it crosses the old bed of the Yellow River and runs in a northwesterly direction to the borders of Shantung and beyond, eventually reaching Peking.

The main object of this canal was the safe transport of tribute rice, foodstuffs and treasure from the rich lands of the south to the Imperial Court at Peking, the passage by sea from Shanghai or other ports to Tientsin, the port of Peking, in Chinese junks, being attended with much danger from both the sea and pirates. The loss in grain, treasure and life (named in the order of their importance) was so great that the expenditure necessary to construct the canal and operate it was justifiable at the time. The present canal was completed during the Mongol dynasty, and for six hundred years afterward, until the arrival of coast steamers and later the railways, was of great value. Even at the present cate, although the through traffic to Peking has been discontinued, the canal is of immense importance as a transport route to the country through which it runs, and would well repay the cost of being put into thoroughly good repair and of being well maintained.

The only part of the canal now under consideration is from the Shantung border to the Yangtsze. The width is from 200 to 400 ft., and the depth from 2 to 10 ft., depending upon the locality and the time of the year with reference to the water-supply. The water is confined between artificial embankments, and in much of its length not only is the surface of the water much above the level of the adjacent country, but in many parts the bed itself of the canal is so too. This difference in elevation varies from 0 to 20 ft. or more, and as the Chinese up to the present time have expended all their labor in increasing the height of the dikes and none upon lowering the canal bed, the condition becomes worse each year and the danger more imminent.

The line of the canal crosses the dip of the country at a large angle, and consequently for the whole of its length

FIG. 2. FED ON BARK, LEAVES AND GRASS

FIG. 3. REQUIESCAT IN PACE

FIGS. 2 AND 3. RESULTS OF FAMINE IN CHINA

from Nan Wang Changtcha in Shantung where the water divides, some flowing north and some south to the Yangtsze River, a distance of 500 miles, the canal with its high artificial dikes acts as a dam to all the natural outlets to the sea for the rivers having their sources on the west side, the most important of these being the Huai River.

The successful handling of the Grand Canal, in the maintenance of unbroken transport facilities, a minimum allowable depth, a carefully regulated water-supply and the passing of the Huai River floods through it, is one of the most important and delicate problems of the proposed conservancy.

The canal acts as a great obstruction to the passing away of the heavy rainfall which causes the floods, the long duration of which is caused to a great extent by the canal, and reacting, are the greatest source of danger to the canal and the greatest source of damage to it, being a constant menace to its dikes, which if broken on the eastern side endanger the entire usefulness of the canal, and even if the breaks do occur is the embankment of the Tientsin-Pukow Ry., which, as will be seen on the map, extends north from Peng-pu, on the Huai River, to Suchow-fu, in the province of Honan, crossing the line of the dip of the country at an angle of 60 degrees more or less. This embankment is from 10 to 40 ft. in height, and forms a barrier to the natural flow of water in times of flood. A most careful study, of flood conditions and the amount of water to be handled was made by the railway engineers, and as far as could be foreseen ample openings have been made for the passage of the flood waters in such a manner as to prevent serious damage to the railway embankment, and the great floods of 1910 and 1911 passed without breaking this embankment; but whereas before its construction the flood water flowed from the northwest to the southeast in one vast sheet and the floods subsided in days, now the water having to flow south and pass through definite openings is much retarded in its subsidence, and possibly weeks are required.*

FIG. 4. REPAIRING DIKE ON GRAND CANAL

FIG. 5. BORROW PITS MEASURED TWICE A WEEK

FIG. 6. TAMPING NEW EARTHWORK

FIG. 7. RELIEF WORKERS AFTER ONE MONTH ON JOB

FIGS. 4-7. FAMINE-RELIEF WORK IN CHINA

(The borrow pits shown in Fig. 5 were measured and the excavation paid for twice a week. The price was about 20c. in gold per Chinese Feng equal to about 4½ cu.yd. Tamping disks, such as is shown in Fig. 6, made of iron or stone, are universal in China. They are also used to drive small piles.)

much of the flood waters are of necessity obliged to find an outlet through the canal, as the canal itself cuts off all other outlets; and thus each year, during the months of June, July and August at least, the canal is required to carry away an amount of water much beyond its maximum capacity. This is a source of great danger to its dikes, and even if they do not break they are likely to be badly damaged, and a great quantity of silt is deposited which makes desirable the dredging of the channel (which is never done), or the increasing of the height of the dikes (which is sometimes done). As a matter of fact nothing is usually done until a serious break occurs in the dikes, much damage is done to the low (Hai) country, and valuable crops are lost with some lives, and then the repairs are made in a weak, cheap, temporary manner at a tremendous cost. With proper outlets the flood level would be lowered, the length of duration of the floods reduced, the land drained, and the danger and damage to the canal reduced to a minimum.

THE TIENTSIN-PUKOW RAILWAY EMBANKMENT—Within the last few years a new and disturbing feature has been added to the topography of North Anhui, which requires careful study with regard to the conservancy scheme. This

THE PRINCIPAL CAUSES OF THE FLOODS

The entire Huai River catchment area discharges its waters into the Hungtze Lake. The bed of this lake is comparatively high, and is slowly being raised each year by the deposit of silt which it receives from the Huai and the other less important rivers coming in from the north and northwest. It may be said, however, that the percentage of silt held in suspension by the flood waters of this region is small as compared with that of such rivers as the Haiho at Tientsin, the Yellow River and the Yangtsze, but what there is deposited in the Hungtze Lake, which has no adequate outlet. The floods come from the west, northwest and north. The country has a minimum of dip and no outlet, therefore the greater part of the inundation in North Anhui is not due to the rivers overflowing their banks, but is caused by the backwater of the Hungtze Lake and the lower reaches of the Huai, due to the fact that neither the Huai nor the Hungtze Lake have an outlet at all in proportion to the immense amount of water which is poured into them in a short period of time.

*This statement is not made as the result of personal observation, but from data given me by foreign missionaries and natives living in sections affected.—C. D. J.

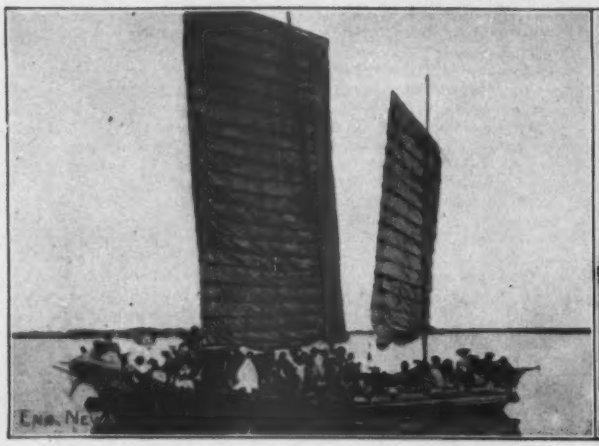


FIG. 8. COOLIE TRANSPORT—HUNGTZE LAKE

FIG. 9. CHINESE GUNBOAT—HUNGTZE LAKE

FIG. 10. FERRY ON GRAND CANAL

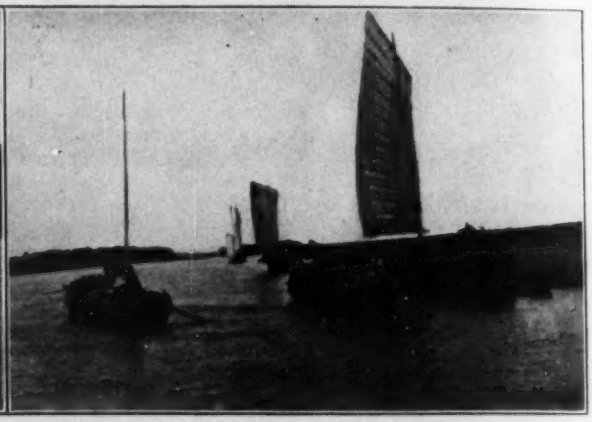


FIG. 11. BOATS ON GRAND CANAL

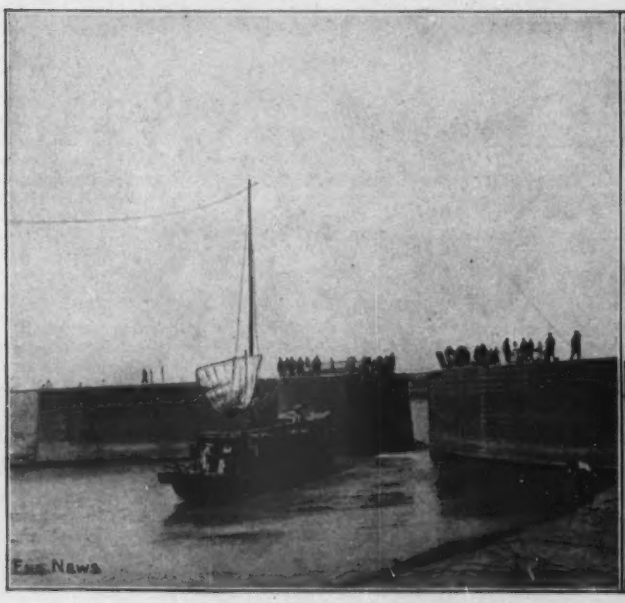


FIG. 12. LOCK ON GRAND CANAL

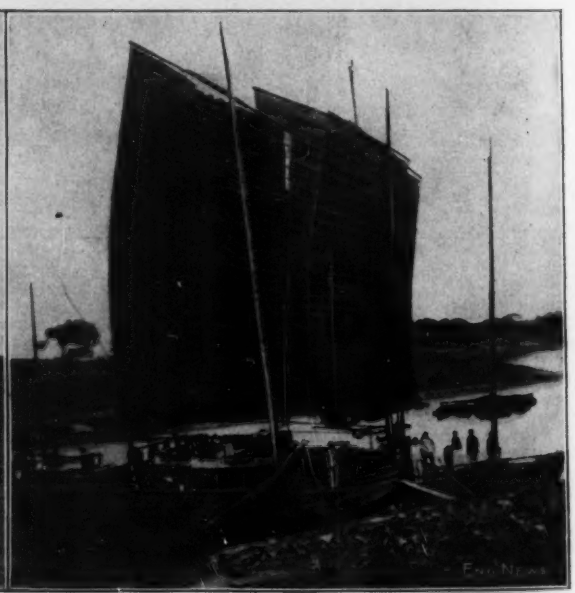


FIG. 13. HOUSE BOAT

FIGS. 8-13. CHINESE BOAT SCENES ON LAKE, RIVER AND CANAL

(The gunboat shown in Fig. 9 carries one officer and 12 men, one small cannon in the bow, and has 12 oars. The lock shown in Fig. 12 is 24 ft. wide and is the principal outlet of the Huai River at the east end of Hungtze Lake—see map, Fig. 1. The sails of the house boat, shown in Fig. 13, have bamboo ribs and are held to the mast by pieces of split bamboo. Separate sheet lines run from the end of each rib.)

PROPOSED RELIEF WORKS AND STUDIES

It must be understood in all that is said in this report as to the lowering of the flood level and the practical elimination of the floods, that it applies to normal floods, such floods as occur every few years, or year after year in some cases, destroying the crops and impoverishing the people. Such floods, and consequently the damage done by them may be done away with, but at times there comes an abnormal flood or cataclysm, which sweeps before it any work of man. Such floods cannot be eliminated, but there is always the chance that such horrors may never arrive.

SURVEY—The first thing is the hydrographical survey of the sea coast from the old mouth of the Yellow River to Haichow, to determine the most suitable points of discharge for the Shu River, the Yi River and the new outlet to the Hungtze Lake down the old bed of the Yellow River.

THE SHU RIVER—With regard to the Shu River there appears to be no necessity for control or regulating works beyond small sluices controlling the entrance of the drainage canals. The main features of the conservancy of the Shu are to give it a clean, well defined channel to the sea, and to see that this channel and its mouth are not allowed to silt up. The channel should be excavated sufficiently below the land surface to drain the country and swamps through which it runs.

THE YI RIVER—With regard to the Yi River its natural outlet is by the Grand Canal to which it supplies water. The new flood channel should be cut through the Loma Lake, and

FIG. 14. READY FOR AN OVERLAND TRIP IN CHINA

(C. D. Jameson, with "head boy" and Chinese farm wagon on American Red Cross Engineering inspection trip.)

thence by the best route to the sea, probably utilizing and improving some already existing water course. The different branches of the Yi River to the Grand Canal, at the points where they leave the main river, should all be supplied with regulating gates in such a manner that the amount of water passing into the Grand Canal can be under proper control. This also includes gates where the flood canal branches from the main river to the Loma Lake. By this means only the requisite amount of water will enter the Grand Canal, and in the dry season the entire discharge of the Yi River will be available, while during the rainy season all excess of water will be carried away by the flood canal.

HUNGTZE LAKE AND THE HUAI RIVER CONSERVANCY—In the final disposition of the flood waters of the Hungtze Lake and Huai River systems certain important questions must be considered as to the absolute control of this disposition. All of these waters are drained into the Hungtze Lake, and from this basin two outlets are provided: (1) The Canal via Tsiang Kia-pa to the Yangtsze west of the Grand Canal.

(2) The Canal to the east through the old bed of the Yellow River to the sea. These two outlets will branch from the undrained portion of the Hungtze Lake, and of the two the one to the east should have the greater capacity, as during a flood it would be by far the more important.

THE YANGTSZE FLOODS—At times heavy floods occur in the Yangtsze basin and the Huai basin simultaneously, but fortunately this is not always nor even often the case. When the Yangtsze is in great flood the utility of the Tsing Kia-pa canals as flood canals would be decreased, and the greater portion of the Hungtze Lake surplus would be run off through the canal to the east.

REGULATING AND CONTROL WORKS—In years of low water in the Yangtsze and floods in the north, the amount discharged by the two canals should be so regulated that the Yangtsze canal would carry a safe maximum.

What remains of the Hungtze Lake after being drained to a certain level would serve, in an emergency, as a storage basin for the floods from the north and west, and from this basin lead the two outlet canals.

At the inlet to each of these two canals must be regulating sluices for the perfect control of the amount of water passing into each canal, and in connection with this regulating work there should be a suitable chamber lock for the passage of boats each way at all times.

PERMANENT ENGINEERING DEPARTMENT RECOMMENDED

The most immediate need in the Huai River and Lakes Conservancy is a well organized engineering department.

The surveys already made by the Chinese survey students are of some value, but the organization has no definite head, the control is very loose and haphazard, and the men in control are totally lacking in all technical knowledge of the requirements of the problem, of the methods necessary in the mere matter of surveys. Much time and money has been expended on relatively unimportant work, while the essential and urgent work has not been done at all. The office records of work done in the field are hopelessly in confusion. All these faults may be remedied with reorganization, method and discipline, and several well organized engineering parties should be put into the field at once.

So far the work of conservation has been considered by the Chinese merely from a provincial standpoint, and in the work done so far, Anhui and Kiangsu are intensely jealous of their own provincial rights, to the great detriment of the work. This conservancy work cannot in any way be considered provincial, if it is to be attended by any success. It is and must be of a purely national character, and carried on without the slightest regard for provincial boundaries. Topography and rainfall are the ruling elements to be considered. The administration, engineering, etc., of the conservancy must deal only with the Central Government and draw its funds from the Central Government. In the question of private lands which may be needed for the work, the Conservancy Board should have the right of "Eminent Domain," the price being settled by arbitration, or if necessary the land condemned and the price settled afterward.

In this report it is not necessary to go into the details of the Conservancy Organization and methods of work, but a definite well disciplined organization is needed.

WEATHER BUREAU—One of the most important departments of the Conservancy Organization, and one that should be organized and put into operation as soon as possible is a Weather Bureau, with stations established at all necessary points in the entire catchment area of the river systems under consideration.

When the Conservation and Regulating Works are completed, this service will be absolutely necessary in order that the full value of the work done may be realized. Advance knowledge will be available of the coming of floods, the amount of water to be taken care of, the channels through which it will come, and the moment at which it will arrive.

This Weather Service should be extended to the Yangtsze Valley and also to the Yellow River basin, and the more rapidly this is done the sooner will exact data be available for the regulation of these rivers. This Bureau should be worked in connection with the Weather Bureau of the Siccawei Observatory, Shanghai.

ESTIMATED COST OF WORKS

The estimated cost of the work outlined in this report will be about 35,000,000 Mexican dollars, and the time necessary for its completion—provided no delays are occasioned by lack of money at the time when it is needed—will be from six to seven years.

As to the results which will be obtained after the completion of the work, they will be: the doing away of all but abnormal floods over an area of some 17,000 sq. miles, the draining of this whole area and the lowering of the flood level to such an extent that in all but abnormal years two crops will be possible each year, where, under present conditions, two crops in five years is the rule.

In addition to this improvement in land which is now supposed to be under cultivation, there will also be reclaimed some 6,000,000 Chinese mou of land which is now absolutely valueless, being covered with shallow lakes or swamps.

There will also be a saving of the cost of the annual famine relief, which for many years has been poured by millions and millions of dollars into this section of China.

The moral results will be the elimination of the suffering, starvation and degeneration of several millions of people, who now are fast becoming beggars and robbers; the turning into producers of these millions who now are not only non-producers, but are becoming a menace to the country and cause of unrest and lawlessness.

Cooling a Gas Engine by Internal Injection

The idea of introducing water (not vapor) into the interior of a gas-engine cylinder has been in the minds of engineers for a long time, but there has been a fear that the working gases would be too much cooled by direct contact with water and that useful energy would be locked up in the latent heat of steam and lost with the exhaust, so water jacketing has continued to be the accepted practice. However, a paper before the July meeting of the British Institution of Mechanical Engineers, by Prof. Bertram Hopkinson, of Cambridge University, describes what appears to be a successful use of injection water in place of jacket cooling. His theories have been backed by rather extensive trials under commercial conditions.

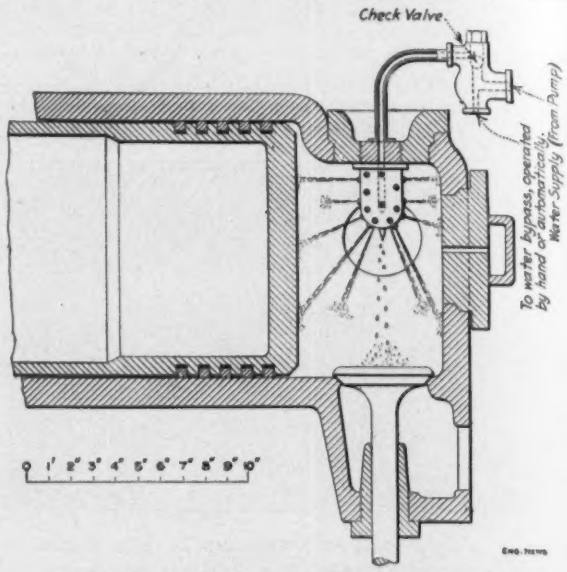
Prof. Hopkinson's contention is that it is only necessary to project the water, without atomizing, directly against the metal surfaces which need cooling. This he does by introducing a rose in the combustion space as shown in the accompanying figure. The water then absorbs very little energy from the charge, being vaporized by heat from the metal walls. The steam thus formed is of no disadvantage and, being superheated, tends to hold up the expansion line. It is necessary to let the working temperature of the cylinder and piston run up to such a point that the water is all vaporized practically as soon as it strikes the metal so as not to wash down the lubricant or to cause corrosion by combination with any sulphur in the charge.

The water should go in just before ignition and stop just after, covering a period when the sliding surfaces of the barrel are largely covered by the piston. This cooling of such a limited amount of metal surface might seem insufficient, but the researches of Dugald Clerk and others are cited as showing that the heat flow into the cylinder walls during the last three quarters of the expansion stroke is so small compared with the first quarter that cooling of the further parts of the barrel can be dispensed with.

To test this scheme, a 50-hp. gas engine (11½-in. cylinder diameter and 21-in. stroke) was fitted with a new cylinder having no water jacket, that being the only change in the machine except the attachment of the water pump. With this arrangement, compressions were satisfactorily reached up to 175 lb. per sq.in. (absolute), though this pressure could not be used with the jacket-cooled cylinder on account of preignitions. The water pump was driven by a cam on the valve shaft giving a stroke once each cycle. The pump stroke commenced 30° before ignition and finished 30° after. Part of the time a very hard water (25.5 grains per imperial gallon) was used so that the combustion chamber and piston face became thickly encrusted, but none collected on the sliding surfaces and there were no preignitions.

In a 120-hr. run on coal gas with this cylinder, the engine developed 43 b.hp., average, under smooth and steady operation; with the water-jacketed cylinder in place, only 40 b.hp., maximum, could be developed and then only with overheating and violent explosions. The average amount of water used for injection was 3.4 lb. per b.hp.-hr., the engine temperature running from 150° to 180° C. The heat abstracted by the jacket water, under similar load, when the jacketed cylinder was in place, was sufficient to evaporate 2.5 lb. per b.hp.-hr. On this 120-hr. trial, the gas consumption was practically the same for both cylinders. Tests for other loads showed that with a lean mixture the gas consumption for injection cooling rose above that for jacket cooling, while with rich mixtures the reverse was true, the differences being within 5% either way.

This engine was subsequently put into factory service on a suction-producer plant and it has regularly developed 50 b.hp. for several hours on a stretch. It has been run for two years (about 5000 hours), being left to itself like an ordinary gas engine. The gas used contains some sulphur, but no trouble has been found in cylinder or piston corrosion. The rose nozzles, however, wasted



HOPKINSON SCHEME OF GAS-ENGINE COOLING BY INJECTION WATER

away rapidly until a special resistant metal was found. Minor corrosion was noticed in the bends of the exhaust pipe and wherever water could accumulate. The cylinder was lubricated with a thick oil such as is used in superheated-steam engines. The combined wear on cylinder and piston nowhere exceeded $^1/_{100}$ in. The engine governs "hit-and-miss," and the pump is connected to the governor also so that it makes a stroke only when the engine gets gas. This gives too much water on starting, but is satisfactory between one-third and full load. Adjustment during starting was first made by a hand valve, and later a satisfactory cylinder-thermostat bypass control was developed.

Failure of the water-supply has given no trouble, as all the engine parts have heated up slowly together until the machine has stopped by preignition. The pistons have not stuck, but as an added precaution against overheating a fusible plug was screwed into the combustion chamber and this lets out the working gases above 200° C.

This scheme was tried on two larger engines, one a 105-b.hp. type (18-in. bore) and the other a 1000-b.hp. (36-in. bore), an account being given in the Institution paper of the latter. The jackets were merely emptied and the injection roses fitted in the combustion space. The pumps delivered water to the nozzles 45°

before and after the in-center. The engines were put back on ordinary work and the temperatures were kept within 100-200° C. under full load. Failure of the water-supply merely caused preignitions and necessitated temporary reductions of load, the engine heating up so slowly that trouble could be remedied before serious results were noted. The amount of water used was 2.4 lb. per b.hp.-hr. The whole injection apparatus cost about $100 and within a few hours of being fitted was doing the work of an expensive cooling plant comprising the cooling tower, pumps, mains, etc., needed for the jacket water.

A complete design of engine harmonious with this scheme of cooling has been worked out and the first engine (two-cycle single-acting type with 18-in. cylinder, 24-in. stroke) has been completed for test.

The Yellow River Bridge, Tientsin-Pukow Ry.

Supplementing our previous description* of the great railway bridge over the Hoang Ho, near Tsinanfu, China, we show herewith a view of the completed bridge and two views of foundation caisson work, and give some additional notes on the structure. It will be recalled from our former article that the rapid current of the river (12 to 15 ft. per sec.) and its liability to floods called for care in the foundation work, to forestall damage from scour. The river piers were, therefore, founded on pneumatic caissons, and most of them in addition have a support of pentagonal reinforced-concrete piles. The caissons were generally sunk to 20 to 25 ft. below river bottom, i.e., to the gravel of an old river bed under

FIG. 1. GENERAL VIEW OF YELLOW-RIVER BRIDGE

FIG. 2. BUILDING ONE OF THE PIER CAISSONS

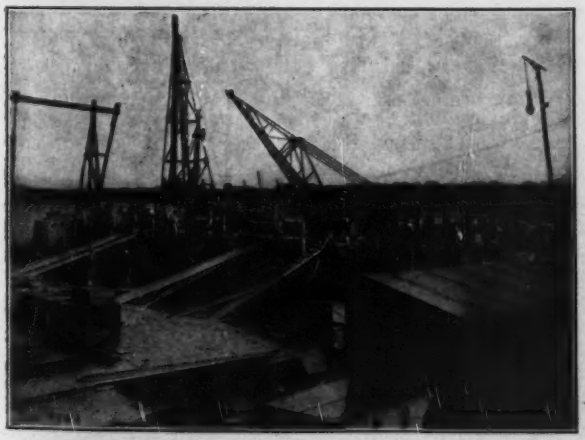


FIG. 3. PILEDRIVING IN CAISSON

FIGS. 2 AND 3. FOUNDATION WORK, YELLOW RIVER BRIDGE

the present stream; 30-ft. piles were driven under some of the piers. The middle pier, however, was founded without piles, the caisson being sunk to 65 ft. below river bottom, or about 82 ft. below low-water level. The shore piers and abutments were generally founded direct on reinforced-concrete piles.

In accordance with prevalent German usage, the piers were faced with stone over the concrete hearting.

The steel superstructure is shown as to type by the view of the completed bridge, Fig. 1, herewith. It is 4117 ft. long between abutments, with main span of 540 ft., two channel side spans of 420 ft., and nine approach spans of 300 ft. each. The steelwork weighs about 8700 tons.

⁂

Authority to Order Municipalities to Build Destructors for Domestic Garbage has been vested in the Board of Health of Victoria, Australia, according to "The Commonwealth Engineer" (Melbourne, Australia). The journal named states further:

> The Board has given notice to 32 municipalities throughout the state that they should take steps, either singly or in conjunction with others, to abandon tips and destroy their rubbish by fire. Only seven or eight of the councils have intimated their intention of doing anything. The provision of a destructor capable of dealing with the garbage of a population of 40,000 would cost, exclusive of land, about £8000, which would not be an extravagant outlay for two or three municipalities to undertake jointly. The Health Department is now awaiting the results of inter-municipal conferences.

If we understand our Australian contemporary, the only destructors yet built in Victoria are the two in Melbourne.

Vocational Schools are to be assisted by the State of Pennsylvania, an appropriation of $140,000 having been made for the purpose. This can be used to reimburse all vocational schools for two-thirds of their expenses of the previous year up to a maximum of $5000, provided the State Board of Education approves their organization, control, location, equipment, courses, qualifications of teachers, methods of instruction, conditions of admission, employment of pupils and expenditures. These schools are largely in the anthracite region, having been established by the mining companies, the Y. M. C. A., and correspondence schools.

*"Engineering News," Jan. 9, 1913, p. 61.

Annual Convention of the Road-Masters and Maintenance-of-Way Association

The 31st annual meeting was held at the Auditorium Hotel, Chicago, Sept. 9-12, with a large attendance. It was a thoroughly successful meeting both as to its technical and its social features, and the earnestness of those in attendance is evidenced by the fact that it was voted to abandon attendance at a ball-game trip one afternoon in order to discuss the committee reports. Although only five reports were presented, the discussions were so active and extended that consideration of four of these reports occupied five of the seven sessions. The other two sessions were devoted to addresses and business proceedings.

The meeting was presided over by William Shea (C., M. & St. P. Ry.). At the opening meeting, the President read a brief address, and addresses of welcome were delivered on behalf of the city and the railways, the latter being represented by W. H. Penfield (Assistant to the Vice President, C., M. & St. P. Ry.). At the annual dinner, addresses were made by several railway officials, including W. L. Park, Vice-President of the Illinois Central R.R. There was an extensive and excellent exhibit of railway track material and supplies and a special feature of the convention was that at one session representatives of the exhibitors were given the courtesy of the floor for five-minute addresses.

The election of officers resulted as follows: President, T. F. Donahoe, B. & O. R.R., Pittsburgh, Penn.; Vice-Presidents, C. H. Gruver, C., R I. & P. R.R., and B. C. Dougherty, C., M. & St. P. Ry.; Secretary and Treasurer, L. C. Ryan, C. & N. W. Ry., Sterling, Ill. The next meeting will be held at Chicago in September, 1914.

Combined Organization of Maintenance Forces

This report dealt with the system of having all track, signal, bridge, building and other maintenance and repair work done by the section gang, instead of sending special men or gangs to do special kinds of work. There should be much less time and money spent under such a system, but at the same time if it is to accomplish this result it will require that the section gang include men of much higher grade and pay than the common laborer, while the roadmaster's position will be one of much higher responsibility. The combination of track and signal maintenance has been tried on some roads, and the Union Pacific Ry. was reported to have introduced it extensively, with very successful results. Another road has tried and abandoned it, however, finding that the track was not so well cared for, while the cost of maintenance was as great as (or greater than) before the signal work was included. But as this experiment lasted only three months it was far from conclusive. The committee was opposed to the combined system, on the ground that the railways would not allow the necessary compensation to employ men of such grade as to make the system a success.

There was a spirited discussion on this subject, with expressions of experience and opinion for and against the system. But the arguments in its favor were somewhat the stronger, and there was a general sentiment that the system is one which should be considered and investigated by railway managements with a view to greater efficiency and economy in maintenance. It cannot be carried into effect successfully by the mere issue of an order making the present section forces responsible for signals, etc. There must be a change in organization, and foremen must be trained in special lines.

A careful investigation of this subject would show the defects in the present system of organization of the track department, with conditions of low wages and intermittent employment that do not tend to attract or keep the better class of labor. And it would show probably the practicability of revising the maintenance organization on the basis of greater centralization of authority.

Track Maintenance by Contract

This committee report showed that doing maintenance work by contract instead of by section labor has been tried in some cases, mainly for such work as ballasting, mowing right-of-way, tile drainage and fencing. The idea of the railway officials is that the work can be done better and cheaper under contract, but the report pointed out that the contractor has to make a profit on his work, is usually in a hurry to get it done, pays his foremen better wages, has better control over his men, and can get more work out of his men. Several members expressed a strong opinion that if railways employed the same class of labor and paid the same wages, their roadmasters could get the same work done better and at less cost than by a contractor.

In the discussion the work was divided into two classes: (1) that which does not involve traffic; (2) that which has to be done under traffic. The former includes mowing and clearing right-of-way, fencing, ditching, clearing station yards, loading gravel at gravel pits, unloading coal at coal stations, caring for switch lamps, etc. One speaker makes a general practice of letting contracts to farmers for mowing the right-of-way, for the reason that ordinary labor is not to be had at the time this work is done, while it is a slack time with the farmers. Written contracts are made, covering five-mile sections of track.

Inquiry was made as to the relative cost of ties treated by contract at commercial plants and by company force at railway plants, but no information was forthcoming, although the C. & N. W. Ry. uses both ties treated at its own plant and at commercial plants. The tie-agent of one road (which has no plant of its own) stated that an advantage to a road having its own treating plant is that it can control the seasoning of ties prior to treatment.

The discussion showed that several members have had work of the kinds in the first class noted above done by contract, usually on a small scale, and with generally satisfactory results when allowance is made for the difference in labor and wages. A resolution was adopted to the effect that work of the first class may be done by contract to advantage.

The class of work which involves dealing with traffic includes the renewing of ballast, ties and rails, the application of tie-plates, and the surfacing of track. One speaker who had considerable experience as an inspector on railway contract work, including track-laying, said that it was an extremely hard matter to get the work done as well as it would be done under the direction of the roadmaster. It was pointed out also that in relaying rail each roadmaster has to organize a complete gang and camp outfit. Perhaps two adjacent divisions will have

only five to ten miles each, but each must organize and train a gang which could as well lay 500 miles. It was suggested that instead of letting such work by small contracts or doing it in small jobs, it would be better to organize one or more gangs to do all rail-laying on an entire road or such part of it as is to be covered in one season.

Many speakers opposed the contract system for work where traffic has to be contended with. It was pointed out, also, that the system of employing cheap labor in railway maintenance work, with green gangs every season, and uniform pay to all men in a gang (whether skilled or unskilled) does not tend to good or economical work.

Mr. Hanson (C. & N. W. Ry.) also emphasized the lack of proper relation of track to traffic. The weight of engines and cars has increased enormously, but the heavy equipment still operates largely over the same track which has carried the lighter equipment. Under such conditions it is poor economy to try to save a little money in maintenance expenses. A resolution was adopted to the effect that it will require several years of experience to prove whether the contract system can be applied successfully to railway maintenance work in which the handling of traffic is concerned.

Accidents in Relation to Track and Maintenance Work

The report of this committee stated that records of the Interstate Commerce Commission for the second quarter of 1912 showed a total of 3398 accidents, of which only 503 were due to track defects, 24 persons being killed and 682 injured in these 503 accidents. Of this number, 182 were attributed to irregular track (bad line, surface or gage), 113 to soft track, 51 to spreading rails, 45 to broken rails, 10 to bad ties, 10 to kinks due to the sun, and 92 to miscellaneous causes (defective switches, frogs, guard rails, road crossings, etc.).

Accidents due to irregular track usually indicate insufficient force for proper maintenance. Those due to soft track and sun kinks would be greatly reduced by a more liberal use of good ballast, for in many cases greater improvement can be made by the application of ballast than by laying new rails. Those due to bad ties and miscellaneous causes may be reduced by the exercise of judgment of the foreman and roadmaster in regard to renewals and general maintenance work. The remedy for spreading rails is largely in the hands of the track department, but many accidents of this class are due to excessive speed of trains, especially at sharp curves, turnouts, etc., and even at points where instructions call for reduced speed.

In the discussion of the report, the President suggested that it be confined to work and safety measures in the track department. For instance, accidents occur on nearly every division to men engaged in the handling of ties and rails, and it is important to consider how these can be avoided. When rails have to be shimmed above a certain limit they should be connected by tie-rods or bars to prevent spreading. Mr. Ryan (C. & N. W. Ry.) said his road purchases frogs and guard rails which are already blocked or do not need blocking, so that the track department has not to look after foot-guards. But a great trouble is that with the low wages now paid, many foremen do not take enough interest in their work to do it carefully or to care whether they keep their jobs. Another member spoke of road crossings with such steep approaches as to be dangerous in tending to stall vehicles at the crossing.

The report mentioned the case of a road which offered $5 reward to every person, not in the railway's employ, discovering a broken rail. This plan is open to very strong objection. In the first place it encourages trespassing (and trespassers form a large proportion of persons killed on the railways), and in the second place it is the railway's own business to see that its track is in safe condition. One speaker said that rewarding a farmer who discovered a broken rail resulted in several false reports being made in hope of reward. The general tendency of the discussion, however, was to deal with the general safety policy of the railways, instead of with the specific work and responsibility of the track department.

Track Material and Appliances

Two committee reports dealt with this subject. The first gave particular attention to the use of manganese-steel in frogs, crossings and switches. The discussion showed generally satisfactory experience, the devices outlasting eight or ten similar devices built up of steel rails, or having a life of three to four years where the rail frogs will last for only three to six months. A resolution was adopted in favor of the use of manganese-steel frogs, etc., in all tracks where traffic conditions are severe. This applies to yards as well as to running tracks, and to spring-rail frogs as well as rigid frogs. The report also approved of one-piece guard rails at frogs.

As to tie-plates, the committee preferred wrought iron to steel or malleable iron. There was the usual difference of opinion as to whether the plates should or should not have ribs on the bottom to secure them to the tie. Some considered that such ribs caused damage and decay of the tie, while others thought they might indent the tie sufficiently to secure a hold without damaging the wood. Some members thought no rib could effectively hold the track from shifting on curves. It was agreed, however, that if flat-bottom tie-plates are used they should be secured to the tie by spikes or screws independent of the rail fastenings. It was the general opinion, also, that tie-plates should be used on all ties.

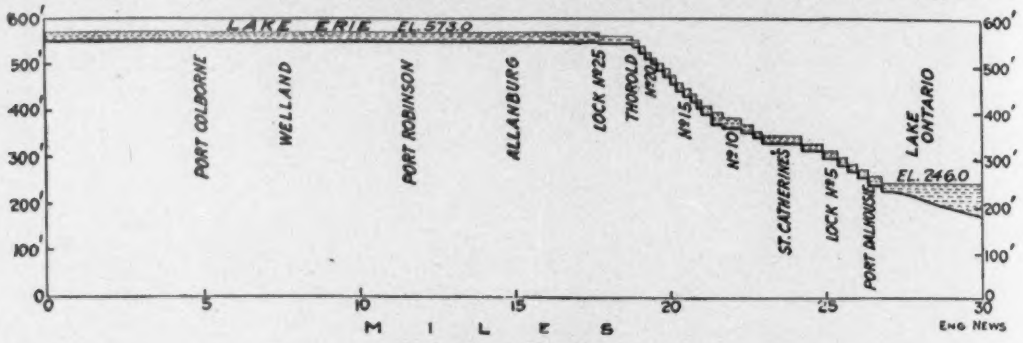
As to switchstands, the automatic type was recommended especially for yard use; but it should operate automatically when latched and locked and when trailed through by a train on either the main track or the turnout. Among other devices noted were: (1) track bolts of steel of high elastic limit (75,000 lb.), which will not stretch and become loose; (2) a ratchet wrench for applying joint bolts; (3) tongs for handling ties; and (4) a portable device for pulling out ties by a cable and hoist, thus reducing the labor in tie renewals.

The second report dealt with power-operated devices, such as motor section-cars (some of which furnish power for operating track tools), gravel and ballast unloaders, rail-handling machines, ballast plows, ditching machines, and pneumatic tools for track work; also snow plows, flangers and devices for melting and removing snow, so as to facilitate the work and reduce the danger of clearing snow by hand, especially at yards, terminals and interlocking plants. There was no time available for the reading and discussing of this report, and it was accepted as information.

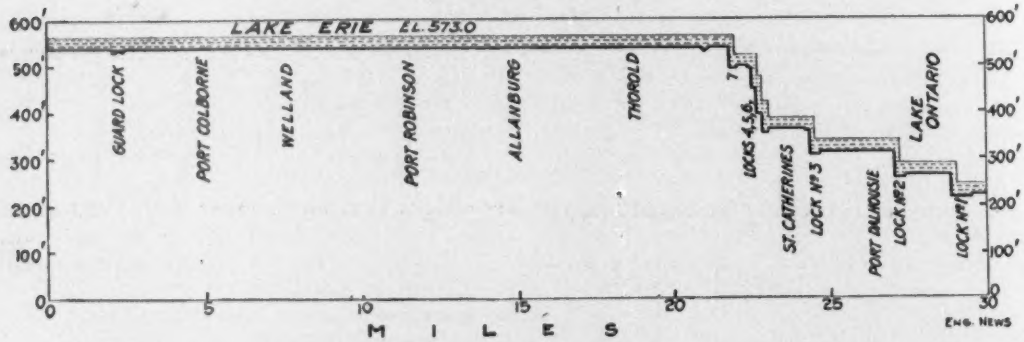
The New Welland Ship Canal

Following a preliminary appropriation of $2,000,000 by the Government of the Dominion of Canada, work has started on the construction of the $50,000,000 Welland Ship Canal connecting Lakes Erie and Ontario across the narrow peninsula between the eastern end of the former and the western end of the latter. The new canal follows generally the same line as the present from Lake Erie to Allanburg, a new line being taken from that place to Lake Ontario. The new waterway will be a ship canal capable of taking boats up to 800-ft. length, whereas the present canal as now operated can carry boats up to a length of 360 ft. During the construction of the new work the present canal will be kept in operation.

The Welland Canal is one of the oldest in Canada, having been started at the time of the great canal agitation in the early '20's of the last century. As originally built it connected its present termini, Port Colborne and Port Dalhousie, but the difficulties of excavation at the so called Deep Cut through the divide in the center of the peninsula prohibited the use of the Welland River or Lake Erie as a source of water-supply and required a summit level fed by a feeder 27 miles long extending from the Grand River, which lies to the west of Port Colborne. Somewhat later, however, the Deep Cut was made and the water-supply taken from Lake Erie, which was and is the summit level of the canal. The lake level is somewhat higher than the Welland River across which the canal is carried in an aqueduct.



PROFILE OF OLD CANAL



PROFILE OF NEW CANAL

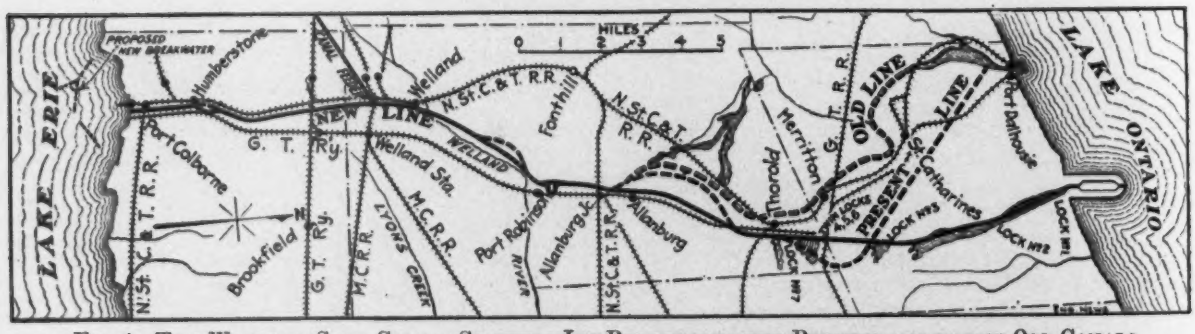


FIG. 1. THE WELLAND SHIP CANAL, SHOWING ITS RELATION TO THE PRESENT AND TO THE OLD CANALS

[From Port Colborne to Allanburg the new line practically follows the old.]

The first canal, of course, was quite small, having locks of wood 100 ft. long and 22 ft. wide. In 1841 an enlargement of the canal was made in which new masonry locks were installed with entrance locks at Port Colborne and Port Dalhousie 200 ft. long, 45 ft. wide and with 9 ft. of water on the sills. The other locks were 150 ft. long, 26½ ft. wide and had 9 ft. of water on the sills. The bottom width of the canal was increased to about 26 ft. In 1860 the canal was deepened to 10

ft. In 1875 a further enlargement of the canal was undertaken. In enlarging the canal this time the old location between Port Colborne and Allanburg, a distance of 15 miles was maintained, the canal prism being widened and deepened to suit the new size. Between Allanburg and Port Dalhousie, 11¾ miles, an entirely new location was selected for the enlargement to the eastward and northward of the old canal. Fig. 1 shows the location of the old canal and the present canal, the present canal being the one which was started in 1875 and completed in 1887. The locks on this enlarged canal are 45 ft. wide at the level of the lower reach and 270 ft. in length between hollow quoins, with 14 ft. of water over the sills. The summit level from Lake Erie to just south of Thorold fluctuates with Lake Erie with an average elevation of 573. From Thorold to Port Dalhousie it drops 327 ft. in 25 locks through the Niagara escarpment to the level of Lake Ontario.

locks are to be 800 ft. in usable length by 80 ft. in width in the clear with 30 ft. of water over the sills at extreme low stages of the lakes. The width of the canal at the bottom will be 200 ft. For the present the canal will be excavated to a depth of 25 ft. only, but all structures are to be sunk to the 30-ft. depth so that the canal can be deepened at any future date by dredging out the reaches. The upper section on Fig. 2 shows a typical section of the canal.

The features of the proposed alignment have been described in a bulletin by the Engineer-in-Charge, Welland Ship Canal, as follows:

The inner harbor at Port Colborne will be deepened to the proposed new depth and the old locks and regulating weir now in the center of the village will be entirely removed. The rock cut from Port Colborne to Humberstone will be deepened and widened on the west side just below Humberstone and a thorough cut will be made across the point now forming Ramey's Bend to materially straighten the canal. The material from this cut will be nearly all rock, and will

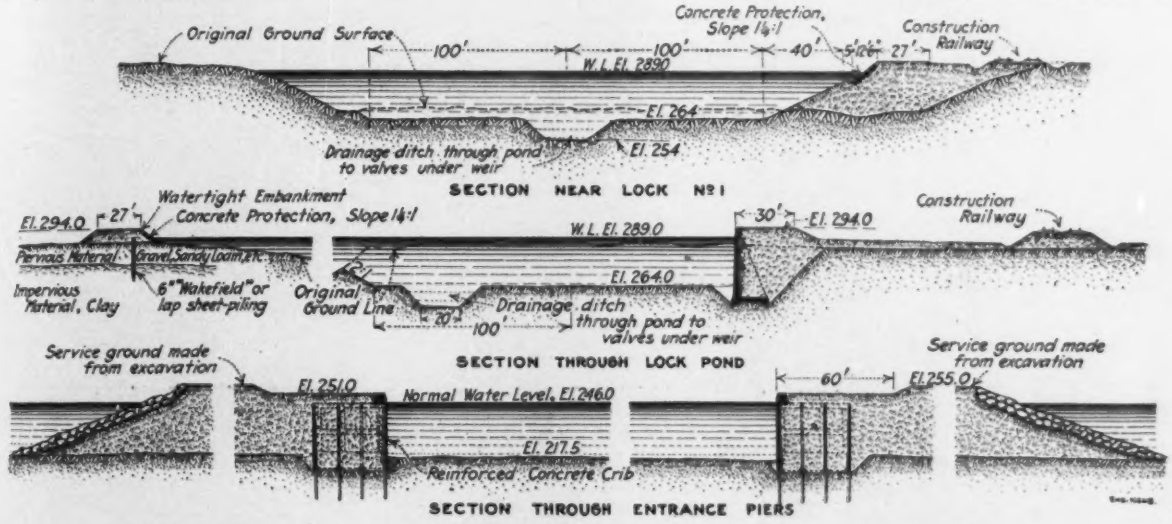


FIG. 2. SECTIONS THROUGH WELLAND SHIP CANAL IN SECTION 1, NEAR LAKE ONTARIO

The old canal is still in existence in the location shown on the map and is used for small vessels and for the power generated.

The proposed ship canal now just started follows the line of the present canal from Lake Erie to Welland with the exception of a small cutoff about three miles from Lake Erie, and from Welland to the point where the present canal leaves the Welland River the new canal takes its alignment in the bed of the Welland River. From the Welland River to Allanburg the alignment is the same as in both the old and the present canal, but from Allanburg to Lake Ontario an entirely new cutting is made on a much better alignment than the present one which it crosses twice and Lake Ontario is reached about three miles east of the present harbor at Port Dalhousie.

The total length of the proposed canal from lake to lake is 25 miles and the difference in level between the two lakes, at low water, 325½ ft., is to be overcome by seven lift locks each having a lift of 46½ ft. A guard lock and weir at Humberstone will control the summit level to the elevation of extreme low water in Lake Erie and will overcome the lift between the summit level and any higher water in the lake. The dimensions of the

be used to form the breakwater previously mentioned. A guard lock will be built in the rock cutting a short distance below Humberstone, and when this new cutting is ready for navigation a regulating weir will be built across the abandoned portion of the present canal which will be used as a bypass to furnish water to the canal. This lock and regulating weir will control the elevation of the summit level of the canal, which it is proposed to keep at the level of extreme low water in Lake Erie, viz: 568 ft. above sea level.

From Ramey's Bend to Welland the canal will be deepened and widened by excavating a strip along the western bank. Instead of building a new aqueduct at Welland to carry the canal over the Welland River, it is proposed to raise the level of the river to that of the summit level of the canal, viz.: 568 ft. by means of a dam across the river at Port Robinson. This dam will be provided with a large overflow and regulating weir which will control the elevation of the summit level, allowing any surplus water to overflow into the old Welland River and pass out into the Niagara River at Chippewa as at present. A sufficient quantity of water will be allowed to run constantly to keep the river clean.

The present aqueduct at Welland will be dredged out, also the bank between the canal and the river, which latter will be utilized between Welland and Port Robinson instead of the present canal, being somewhat straighter and entailing considerably less excavation. At Port Robinson a cut will be made through the present bank between the canal and the river through which vessels will again enter the canal prism.

The raising of the Welland River above Welland will flood some 1600 acres of low land adjoining the river bed. This land is not of any great value, as it is flooded every spring

by the flood water in the river and is principally used for pasturage. The township of Wainfleet adjoining the Welland River on the south side, consists principally of low-lying ground, which drains into the Welland River, and to prevent damage to this land on account of the raising of the river, it will be necessary to open up most of the ditches from the point of their present entrance to the river to the intended high-water mark.

The turning of the Welland River into the canal will pollute the waters which are at present used by the towns of Welland, Thorold and Merritton, and by the city of St. Catharines for domestic purposes. This may necessitate the construction of extensive filtering plants, which scheme is not looked upon with favor by those interested. An alternative scheme to lay a pipe line from Lake Erie to the reservoirs of the different municipalities, through which clean water would be continuously pumped, is under consideration and appears to be the most feasible scheme available.

Between Port Robinson and Allanburg what is known as the Deep Cut (deepest cutting 66 ft.) will be deepened and widened by cutting a slice off the western bank. Allanburg is now the junction of the present and old Welland Canals, and the water required for the latter, which is quite considerable on account of the numerous power developments along it, is taken into the canal through a weir at this point.

In connection with the construction of the ship canal, it is proposed to close the present old canal entirely between Allanburg and Marlatts Bridge near Thorold, first building a new weir at the head of Lock No. 25 of the present canal to supply the above mentioned water. A dam will then be thrown across the old canal at Allanburg, and the old bed of the canal between the dam and Marlatts Bridge will be utilized as a dumping ground in which to place the material removed from above water in widening the deep cut. This will form a very convenient dumping ground, and the old canal will become more self-contained, as at present the entrance works are situated at an inconvenient distance from the remainder of the canal.

If it is desired to continue navigation on the old canal, entrance may be had to it through Lock No. 25 of the present canal when the ship canal is completed by making a short cut through the bank separating the two waterways.

[At Thorold the locks commence, Locks No. 7 to No. 4 being located within a stretch of three miles as described below under "Locks."—Ed.]

From Lock No. 4 the proposed canal crosses the meadow to the north, following in part the bed of the Ten Mile Creek till it crosses the present canal at the foot of Lock No. 11, at an elevation of 382 ft. above sea level, which is the level of the present canal at that point. This will enable small vessels which wish to do so, to use the Port Dalhousie entrance as at present, as far as Lock No. 11.

Below Lock No. 3 a heavy cutting is required through the village of Homer to the bed of the Ten Mile Creek again, above Carleton St., and just below Carleton St. Lock No. 2 is located. The pond at the head of Lock No. 2 is at an elevation of 325½ ft. above sea level, and floods about 200 acres of land in and adjoining the bed of the Ten Mile Creek. Below Lock No. 2 the canal follows the bed of the creek to the lake, Lock No. 1 being situated just below the Lake Road, and only a short distance from the entrance to Lake Ontario.

Locks

As stated before, each lock is to be 800 ft. long and 80 ft. wide with a depth of 30 ft. of water over the gate sills. They are to be built throughout of concrete founded on bedrock. The lock walls will be 82 ft. above the top of the gate sill and, including the necessary foundation work required below this level, two of the locks will have walls 100 ft. high. The lock gates are notable in that they are of the single-leaf type swinging on a hinge at one side of the lock and resting in a notch cut in the opposite wall. The gate at the foot of each lock will be 83 ft. high, 90 ft. long and will weigh about 1100 tons. As designed, the valves and culverts will allow the lock to be filled in less than 8 min., which will reduce the time of passage very materially under that required in the present canal system.

Locks Nos. 4, 5 and 6 are in flight and in order to give them a traffic capacity equal to the other single locks, they are built in twin flights, one for up-bound and the other for down-bound traffic. At the head of the flight and at the head of each of the single lift locks a pond is provided, which is utilized as a regulating basin from which water to fill the lock is to be drawn. This method of drawing water from a side pond instead of directly from the canal above avoids the formation of objectionable current and surges in the canal and locks and is the method adopted for filling all of the locks.

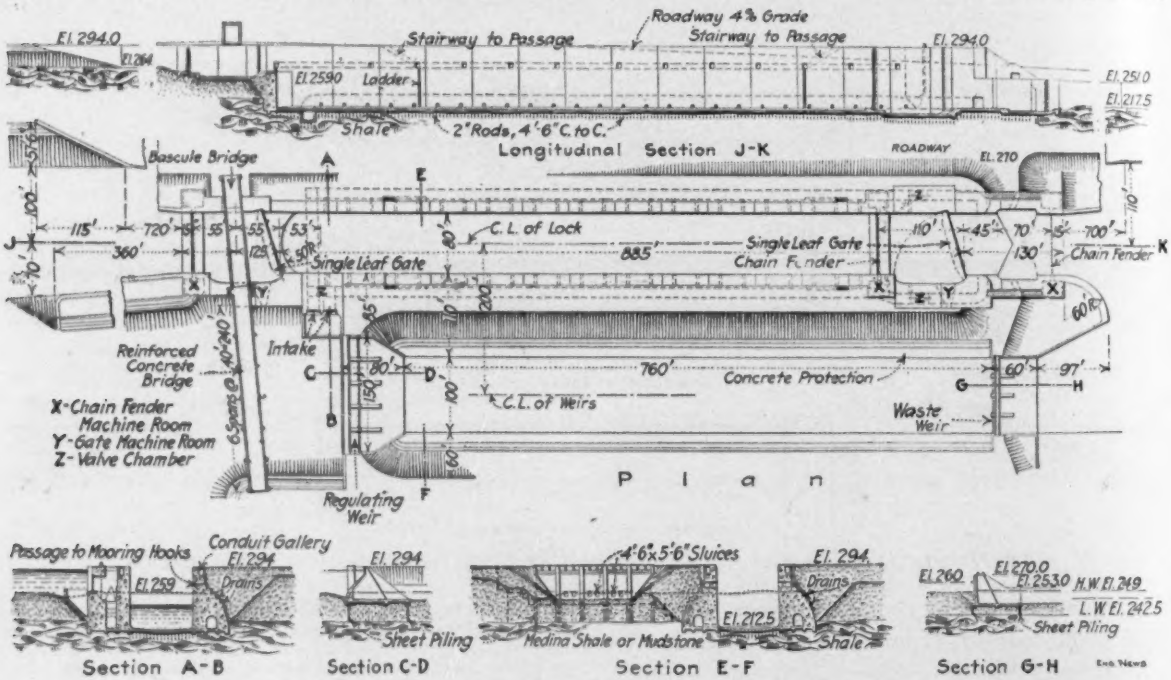


FIG. 3. DETAILS OF LOCK NO. 1, WELLAND SHIP CANAL

Fig. 3 shows the details of Lock No. 1, which is in the first contract to be started. It is in general typical of the other locks. In it the particular points to be noted are: the regulating channel to the side of the main lock with its two wiers dividing the total fall (regulating wier at the head and waste wier); the single-leaf gates; the chain guards or fenders above and below the gates; the culvert connections between pond and lock and the concrete bridge, with draw span, across the lock.

Fig. 4 shows sections through two of the twin locks. Locks No. 4 being founded on shale are built with gravity section walls, whereas Locks No. 5 and 6 being in a good quality of sandstone are designed with a 5-ft. concrete facing to the rock to form the lock chambers. This method prohibits the use of side culverts, so bottom culverts, as shown in Fig. 4, have been used in these two lock systems.

Special features of the several locks are as follows:

Beginning at the south of the canal the first lift lock is lock No. 7 at the north end of the Erie level. As

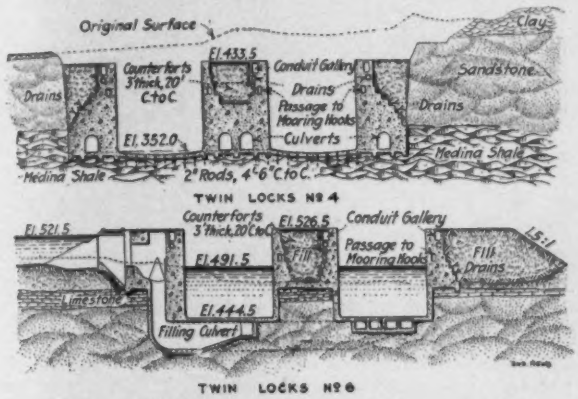


FIG. 4. TYPICAL SECTIONS THROUGH TWIN LOCKS 4 AND 6

(Lock 4 has concrete walls and side culverts; locks 5 (not shown) and 6 concrete facing to natural stone walls and bottom culverts; see text.)

a special protection to the summit level, a pair of twin guard gates are located here near the southerly limits of the town of Thorold, and a short distance south of lock No. 7, the head of this lock being directly opposite the head of lock No. 24 of the present canal. That portion of the present canal between locks No. 25 and 24 together with a pond of about 27 acres formed by flooding the upper valley of Ten Mile Creek will be utilized as a regulating basin.

Below lock No. 7 is a short reach of canal with an adjacent side pond having a surface area of about 84 acres and immediately below are located twin locks Nos. 6, 5 and 4 in flight. These three locks overcome a descent of 139½ ft. One flight will be used for downbound vessels and the adjoining flight for upbound, a double flight being required to save long delays in the passage of vessels through the canal.

Lock No. 3 is located immediately north of the present canal and at its head on the east side is situated the equalizing basin, a pond of 150 acres. Below lock 3 a heavy cutting is required through the village of Homer to the bed of the Ten Mile Creek again and just below lock No. 2 is located. It was difficult to find a location for this lock on account of the lack of rock for foundations, but eventually a suitable foundation was found at the present site. As stated before, lock No. 1 is situated just below the lake road, near Lake Ontario. The pond at the head of lock No. 1 covers an area of 107 acres. A section through it is shown at the bottom of Fig. 2. On the left is the regular slope and on the right the reinforced-concrete retaining-wall fill.

BREAKWATERS

A new western breakwater consisting of an immense rubble mound of stone from the excavation north of Port Colborne, and terminating in a timber and concrete head-block located some 2000 ft. farther out in the lake than the present breakwater, will be built to insure quiet water in Port Colborne harbor during storms. The entry is apt to be rough at present, the breakwater not being far enough out in the lake to deaden the swells.

At Port Colborne the outer harbor is now 22 ft. in depth at ordinary stages of the lake, so that the deepening of this portion of the harbor will be left for a few years until the connecting channels of the Great Lakes allow deeper navigation. The inner harbor of Port Colborne will be deepened to the proposed new depth and the old locks and regulating weir now in the center of the village will be removed.

At the north end of the canal, the outer entrance piers in Lake Ontario are placed about 1½ miles from shore where the depth of water is 30 ft. A wide channel will be dredged from these piers to lock No. 1. The sides of this channel will be protected at the outer and shore ends by reinforced-concrete cribs (see bottom section in Fig. 2) with concrete superstructure along which vessels may lie. These cribs will be built on shore, launched and towed into position. The wooden false bottoms, which are held temporarily by an arrangement of struts and wedges, will be removed after the crib is sunk by a pull on a chain. The cribs will be afterwards filled with spoil. From the shore line of the lake to the outer entrance piers an embankment about 500 ft. in width will be formed on either side of the channel from material excavated from the canal between the lake and Thorold.

CONSTRUCTION RAILWAY

For the purpose of conveying material from the different contracts to the lake the Department of Railways & Canals will build a double-track railway along the west side of the canal from the foot of the flight lock near Merritton to Lake Ontario and temporary trestles will be built in the lake on either side of the harbor from which to start the dump. The railway will also be utilized to haul crushed stone from the site of the flight locks to locks Nos. 1, 2 and 3 where it will be used for the purpose of making concrete.

The Welland division of the Grand Trunk Ry. is situated just where the new twin locks are to be built, and it will be necessary, therefore, to divert it some distance to the west, the diverted line bearing the same relation to the proposed canal as the present line does to the present canal. Wherever road or railway crossings over the canal are required, bascule lift bridges will be used, except in two cases where the roadway is carried on the single leaf-lock gates. Where possible, crossings are located over the head or foot of the locks to shorten the length of the bridge.

The contract for Section No. 1, covering Lake Ontario entrance and Lock No. 1, has been awarded to the Dominion Dredging Co., Ltd., of Ottawa, at prices which aggregate three and one-half million dollars. The contract for Section No. 3, amounting to ten million dollars, has been awarded to Messrs. O'Brien & Doheny, of Montreal. It is expected that contracts for the remaining seven sections will be awarded this Fall.

The maintenance of the present canals and the construction of the new Ship Canal are under the direction of the Department of Railways and Canals, Dominion of Canada, W. A. Bowden, Chief Engineer, J. L. Weller, who has for many years been connected with the Canadian canal system is Engineer-in-Charge of the Welland Ship Canal work.

An Oak-Keyed Belgian Block Pavement

Two great objections to Belgian block pavements are the tendency of traffic to wear off the edges of the blocks, giving each a convex surface, and the incidental noisiness which comes from heavy wagons rattling over the roughened surface. These objections result in time with almost any kind of filler used in ordinary construction. The old blocks with badly worn and rounded edges have been considered valueless for further use as paving material, and in every large city thousands of such blocks are annually scrapped or broken up for concrete aggregate.

To make use of these old worn blocks and yet have a comparatively noiseless pavement a novel kind of construction has been employed and already given from two to three years' trial on heavily traveled streets in Brooklyn Borough, New York City, Baltimore, Md., Boston, Mass., Norfolk, Va., and other cities. This new pavement, a combination of white oak keys and worn Belgian blocks, was invented and patented by Edward Alcott, a lumber manufacturer of Manassas, Va., and appears to have several good qualities.

Fig. 1 shows the patented idea, which consists in placing on all sides of each stone block a white oak key,

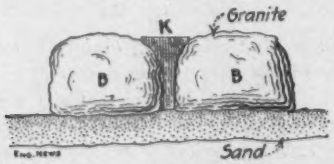


FIG. 1. OAK-KEY FILLER FOR WORN BELGIAN BLOCK PAVEMENT INVENTED BY EDWARD ALCOTT

shaped approximately to the contour of the worn block. The aim is to provide a wedge-shaped filler, which will project sufficiently to cause the traffic to exert its greatest abrasive effect upon the center "humped" portions of the rounded Belgian blocks, wearing off the humps and redeeming the blocks. The oak keys are made in four sizes, measured by the width of the top surfaces, 2½, 3, 4 and 5 in.

Fig. 2 is from a photograph of a pavement laid in Howard St., Baltimore, Md., over two years ago. The dark rows are 5-in. oak keys, and the light rows are the granite blocks, separated longitudinally by narrower oak keys. The effect of traffic in wearing off the humps of the old blocks is clearly seen by the light colored or worn portions of the surfaces of the stones. The effect of the same traffic on the ordinary Belgian block pavement, laid on the same foundation, is seen in the pavement between the street-car rails in the upper part of the pic-

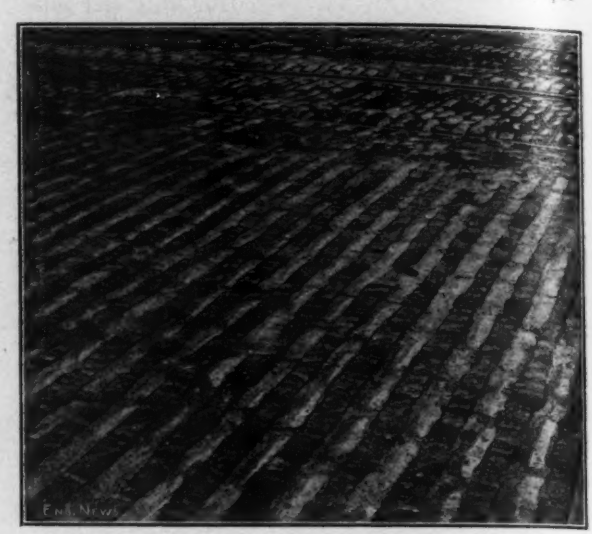


FIG. 2. OAK-KEYED BELGIAN BLOCK PAVEMENT, HOWARD ST., BALTIMORE, MD.

ture. The oak keys have the additional advantage of affording a better footing for horses than cement grout or tar-filled joints.

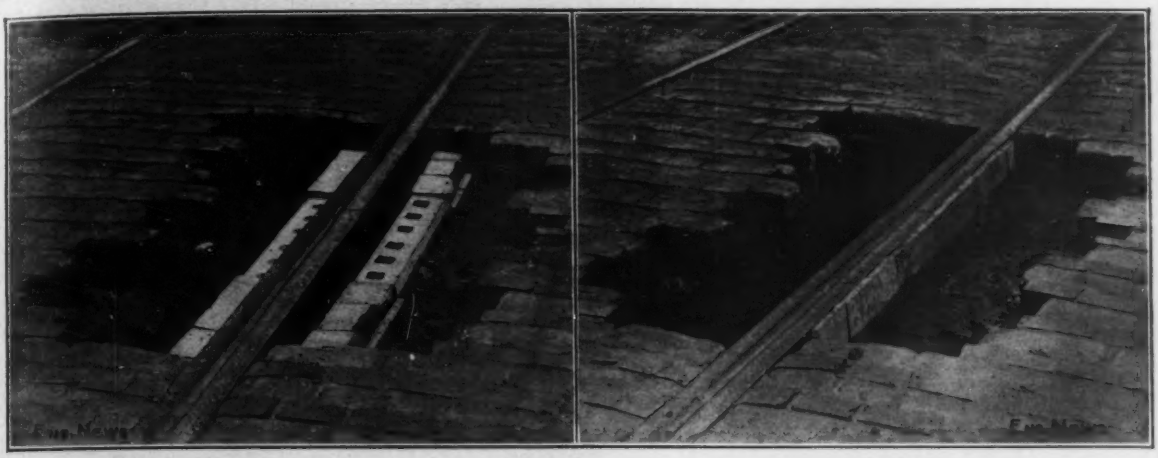
The keys may be either of white oak or other suitable hardwood, quarter-sawed, and so set as to present the grain transversely to the direction of traffic, as with an ordinary type of wood-paving block. The keys are driven between the blocks by ramming as in finishing an ordinary Belgian block pavement. Straight-faced, wedge-shaped keys are used on the courses next to street-car rails or curbings to wedge the blocks to a firm bearing with one another.

The effect of the firmly driven keys is to interlock the adjacent stone blocks, resulting in an arch action which has a tendency to make the whole street surface act as a unit. For that reason it is claimed that this type of pavement serves well on a sand or earth foundation, where an ordinary sand-filled, stone-block pavement would soon develop hollows and humps.

For paving next to the street-railway tracks, Mr. Alcott has invented a specially-shaped block presenting a plain vertical surface on the pavement side from the top of the rail-flange to the top of the rail-head. The inner surface of the block is sawed to the contour of the rail and fits snugly against the upper surface of the flange, the web and the under part of the rail-head. Figs. 3 and 4 show some of these blocks and their appearance when placed in position in the pavement.

These oak filler blocks, being elastic and yielding slightly to the deflection of the rails under the pressure of the car wheels, are claimed to furnish a better binder between the rails and any kind of pavement than is afforded by brick, concrete or asphalt filling. Pavements along car tracks using these filler blocks have been laid in Norfolk, Va. (Figs. 3 and 4) and in Toronto, Ont., and are said to be satisfactory in every particular.

More recently Mr. Alcott has invented an improved filler block designed to protect the fish plates and rail connections in street-railway track from damaging the adjacent paving and to prevent the loosening of the rail connections from vibration. Fig. 5 illustrates this filler and its application. It may be made of any material, wood or metal, but wood is preferable because of its noiselessness and elasticity. In other essentials this style of filler is similar to that shown in Figs. 3 and 4.



FIGS. 3 AND 4. OAK-FILLER BLOCKS FOR PAVING ADJACENT TO STREET-RAILWAY TRACK, NORFOLK, VA.

The cost of this pavement varies with the cost of the stone blocks, so if the condemned blocks having practically no value are used the cost of the pavement is the cost of the oak keys plus the labor of laying the pavement, which requires no more skill than an ordinary Belgian block pavement. In the cities mentioned old Belgian blocks have been relaid with oak keys for considerably less than half the cost of a new Belgian block pavement. If experience proves that the oak keys last and do good service until the stones are worn to a plain surface, when they can be relaid in a first-class Belgian block pavement, the new style pavement will go far toward paying for itself. The cost of the pavements recently laid has been from $1.50 to $2 per sq.yd., depending on the size of the keys and including a 10-year guarantee.

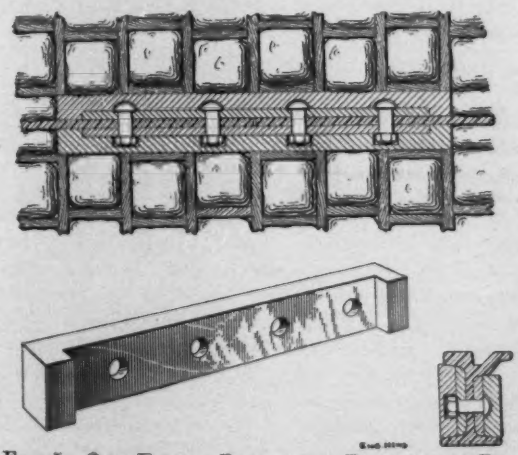


FIG. 5. OAK-FILLER BLOCK FOR PROTECTING RAIL JOINTS IN PAVEMENTS

Recent Improvements in Macadam Road Machinery*

BY A. W. DEAN†

Rollers, tractors and crushers are built today exactly as they were three years ago. Some advance has been made, however, in the motive power for these machines, due to the development and improvements in the gasoline engine. Gasoline motor rollers however, have not superseded the steam rollers to any great extent. While it may be possible that gasoline motors may become quite universally used, it is improbable that it will occur in the immediate future, as there are many features regarding the steam engine that cannot be readily equaled with the gasoline engine, and furthermore, there has to be overcome the prejudice of machinery users against the gasoline engines, due perhaps to the many examples of what might be termed the fickleness of these engines when used to propel automobiles.

DRIERS—As the construction of mixed bituminous roads becomes more universal, there is an increase in the demand for suitable mechanical driers for drying the aggregate, and mixers for mixing the aggregate with the bitumen. The old method of drying stone, gravel or sand, by spreading on sheet iron under which a fire is kept burning, has many times been demonstrated to be unsatisfactory, and it is quite the universal practice at this time to use some form of drier that will mechanically keep the material in motion and thus prevent one portion from becoming extremely hot and another portion insufficiently warmed.

A form of drier which has become quite generally used, is similar to a large concrete mixer, the material to be dried being kept constantly in rotation, and heated and dried by means of a blast of hot air created by means of oil burners, the burners of course much magnified in size and volume.

MIXERS—Improvements have been made also in mixers for incorporating the bituminous material with the dried mineral aggregate. These mixers are an adaptation of the long used standard concrete mixers, and are almost identical with them except that a blast of hot air is constantly forced into the mixer in the same manner as outlined above in the case of the driers. Several devices for heating bitumen have been evolved, but they are all improvements or enlargements on forms of heaters that have been in use for the purpose for many years. Labor- and time-saving devices have been added.

HEATERS—One marked improvement in heating kettles is the addition of a chamber above the reservoir containing the heated material, in which chamber the barrels in which the bituminous material is shipped are placed, so that the heat that might otherwise be wasted, passes into the chamber and warms the bitumen in the barrels to a sufficient extent so that it will flow into the hot reservoir, thereby keeping up a much more constant supply of hot material than could be kept by the old method, wherein the reservoir was filled and drained intermittently.

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*Abstract of a paper presented before the Permanent International Association of Road Congresses, London, 1913.

†Chief Engineer, Massachusetts Highway Commission, Boston, Mass.

OIL AND TAR DISTRIBUTORS—Perhaps more attention has been given by road men to oil and tar distributors than to any other form of road machinery, and there have been placed upon the market more than a dozen forms of distributors, each claimed to be unique and of such superiority over any other distributor that it warrants securing patent rights. They all appear, however, to be only improvements over old devices, or adaptations of machinery used for other purposes to the distribution of bituminous material.

In the manufacture of a machine for distributing hot bitumen, there are two essentials that must be considered. First, a sufficient amount of pressure to cause the material to spray or spread uniformly, and second, provision for keeping the pipes and nozzles clear when the machine is not in action, in order that there may be no obstruction of material when it is desired to start the machine. This latter result can be and is obtained when steam is present as a motive power or as the power for creating pressure, by having the pipes and valves so arranged that whenever the machine is stopped for any purpose, all material remaining in the distributing pipes can be forced out, leaving them free and clear so that when the valve is opened again, the heated material can be forced through. The method adopted by some makers of distributors is to incase the distributing pipes in a jacket pipe, into which steam is introduced, thus heating the inner pipes in which the oil flows.

Pressure for spraying or spreading the bitumen is secured by varying methods. One form in quite general use is to introduce steam directly into the tank of a tank wagon, the tank being constructed of sufficient strength that pressure up to one hundred pounds or more will be sustained. Another similar method in quite general use, and which is adapted to the heavier bitumens, is to introduce air pressure instead of steam into the tank, the air pressure being created by an air pump attached to a roller or tractor used in hauling the distributor.

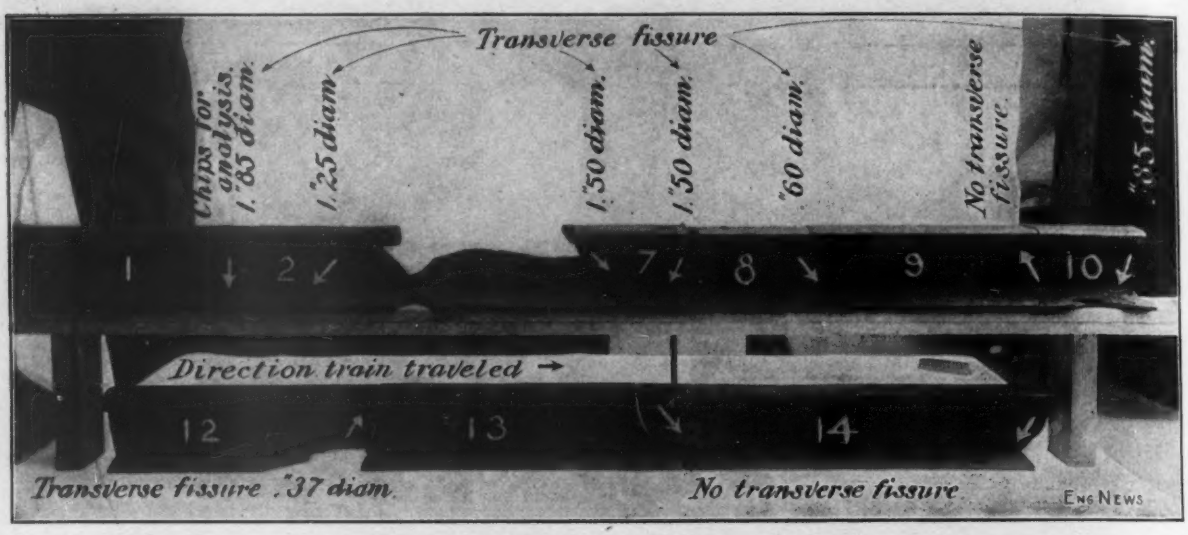
The air pressure is more desirable in many instances than the steam pressure in a tank, for the reason that there is no condensation that can cause the material to froth if allowed to cool and again heated.

Another method of securing pressure for distribution is by drawing the material from the tank and forcing it upon the road by means of pumps. One or two forms of distributors have a gasoline driven pump mounted on the rear of the tank. Other forms have gasoline pumps mounted on two wheels that may be attached by flexible poles or pipes with flexible joints, to the rear of any steel tank wagon. Steam pumps are also used either mounted on the rear of a tank wagon, or mounted on wheels and connected in the same manner as described above in the case of gasoline pumps. Each form or type has its advantages and disadvantages. A gasoline power pump cannot well be used for cleaning the pipes and nozzles, consequently, when very heavy bitumen has been used, it is necessary to have a roller, tractor or other form of steam power present when the work is going on. With a steam pump, the pump is operated by steam directly from the roller or tractor which draws the outfit.

A Rail Broken in Fourteen Places

A report has recently been issued by the engineer-physicist of the U. S. Bureau of Standards, James E. Howard, on a train derailment on the Louisville & Nashville R.R. near Hays Mills, Ala., Oct. 1, 1912. This was a fast passenger train made up of an engine, mail car, two baggage cars, express car, four coaches and two pullmans. The report shows that the train was derailed by reason of a fractured rail. One person was killed and 21 injured.

The fractured rail was an 80-lb. openhearth section, 33 ft. long, rolled by the Tennessee Coal & Iron Co., in June, 1906. The receiving end remained intact for 13 ft. 4 in.; the leaving end was broken into a number of fragments, 18 of which were recovered, the principal ones ranging from 7¼ to 36 in. in length. The rail was



PART OF THE BROKEN RAIL WHICH CAUSED THE HAYS MILL ACCIDENT, OCT. 1, 1912

fractured across the entire section at 14 places. At 11 fractures, transverse fissures were seen and two others were found during tests of the rail. The specifications under which the rails were furnished required a chemical composition as follows: carbon, 0.55-0.68%; phosphorus, not over 0.06%; silicon, not over 0.20%; manganese, 0.80-1.10%. It was reported that the attained composition was within these figures but analyses of the rail showed a carbon content varying from 0.84 to 0.88%. An additional carbon examination was made of metal from the nucleus of a transverse fissure but the carbon content was 0.85%, showing composition normal with the rest of the rail. The rail appeared sound so far as quality of the metal went. Six cross-sections were polished and etched with tincture of iodine, and the etched surfaces were uniform in appearance. Microscopically the metal appeared to have no defects at or in the vicinity of the nuclei of the fissures.

The report has the following remarks on the formation of these fissures.

Transverse fissures have been described in earlier reports of rail fractures and the causes described which are believed to lead to their development. The insidious character of these fissures and their menace to safe travel by rail justifies further remarks upon the probable manner of their formation.

This type of fracture seems confined and peculiar to those conditions which affect steel rails. So far as known, internal

progressive, transverse fissures have not been found in other examples of structural steel, nor have they been found in steel rails which have not been in service. The combined bending stresses and intense wheel-contact stresses which attend service conditions of a steel rail appear to constitute the features which lead to the formation and development of interior transverse fissures. No other contributory causes have been recognized as being present and active in this connection. Regardless of the grade or quality of the steel, there must be present longitudinal strains which cause the separation of the metal of the rail in a longitudinal direction. But the magnitude of those strains necessary to cause rupture will be greater or less according to the grade of the metal.

In earlier periods of railway practice, rail of lower physical properties were used and failures of another kind were then prevalent. Cold flow of the metal occurred. With increase of wheel loads harder steels were introduced to check this tendency. But the formation of interior transverse fissures has made its appearance as a consequence, apparently, of these changed conditions.

The effect of repeated alternate stresses in causing rupture in all grades of steel, without the display of ductility and under the action of fiber stresses somewhat below the elastic limit of the metal, is known. Repeated alternate bending of a steel rail, and all rails are exposed to repeated alternate bending stresses, has a tendency to cause ultimate rupture in a brittle manner under fiber stresses below the primitive elastic limit of the steel.

But exposure to bending stresses alone—that is, unaccompanied by intense wheel pressures on the running surface of the head—would lead to fractures which would have their origins at the fibers most remote from the neutral axis of the rail, where the stresses would be the greatest. Under such circumstances rails would be expected to fracture, starting either at the running surface of the head or at the underside of the base.

Since transverse fissures have their origins at the interior of the head and are longitudinal tensile fractures of the metal, it is necessary to look for a cause for the transference of the incipient place of rupture from the outside fibers to interior ones. The cold rolling of the running surface of the head by the wheels doubtless occasions this transference. The gage side of the head is most affected by the wheel loads, and that should be the side of the head to develop interior fissures, as examples of fractured rail have shown it to be.

The effect of the wheels is to put the metal at the running surface of the head into a state of internal compression. The springing of the head into convex shape on the running side, when detached from the web, is evidence of the release of internal compression. The present rail sprung in that manner when the head was detached from the web. Herein is found a cause which has a tendency to transfer the incipient place of rupture from the surface to the interior of the head. The metal in compression at the running surface must perforce put the metal next below it in a state of tension and augment the tensile strains of the bending loads. In a way the rail is an example of unsymmetrical loading, or rather presents an unsymmetrical result of loading, with bending stresses alone affecting the base, while the head is affected by the combined bending stresses and internal strains of compression.

It is not a question of grade of steel whether or not this action takes place,* but in specific cases a question of what constitutes an overload for the particular steel being used. Rails which develop this type of fracture have certainly been overloaded. The close proximity of transverse fissures to each other precludes the explanation that they are the result of bending stresses taken alone. The results call for the presence of an independent force, the influence of which is felt along the entire length of the head, and such in fact is the manner in which the compression metal acts.

Since these fissures occur in planes at right angles to the direction in which the rails were rolled their formation would not be looked for as a result of mill practice. Certainly the presence of fissures approaching 2 in. diameter would not be attributed to the action of the rolls of the rail mill, ignoring the fact, for the time being, that such fissures are located on one side only of the head. There is lack of continuity in steel in the ingot at places where slag inclusions exist, yet such globules, of one one-hundredth of an inch diameter, more or less, are drawn out in the finished rail into longitudinal filaments parallel to the length of the rail. The examination of rail steel through the successive reductions from the ingot to the rail has failed to furnish examples of incipient fissures developed at right angles to the direction of rolling.

No method has been found capable of locating incipient interior fissures and which, it should be remarked, do not present oxidized surfaces. But so grave a matter as this should not be left in its present state of uncertainty, and data upon contributory causes, track conditions, wheel loads, and grades of steel in which these fissures appear should all be acquired. Primarily the formation of a transverse fissure is the result of an overload, for that particular rail, from whatever point the subject is viewed. It is regarded as an imperative duty, which should at once be performed, to ascertain and define the actual stresses to which the rails are daily subjected.

Structural materials admit of being used with safety, but fundamentally the stresses to which they are exposed must be known. It is difficult to refer to a more flagrant example than that of steel rails where definite knowledge of the actual fiber stresses made use of in service is lacking. The loads which are placed upon the columns of buildings are known with reasonable certainty. Strain sheets show the stresses with which the members of bridges are loaded, and the details of such structures are carefully designed to keep within what are believed to be safe loads.

Experiments which were made nearly two decades ago showed the necessity for conducting observations in the track for ascertaining and defining the fiber stresses in rails due to given wheel loads. The moment of resistance of the rail and the tie spacing not being sufficient data on which to base computations for the reliable determination of the actual fiber stresses under given wheel loads, owing to the yielding character of the roadbed, hence require an experimental determination of the fiber stresses in the track itself. Since those early tests were made wheel loads have been greatly increased and, also bearing on the case, wheel spacing has been changed. It can doubtless be said that definite information is practically lacking in respect to the fiber stresses in rails which are developed by modern equipment, even under static conditions of loading where no obstacle exists for the acquisition of such data. Commendable efforts have been made at different times in the laboratory to acquire reliable information upon the primitive physical properties of the materials made use of in track equipment, but years should not be allowed to pass without corresponding efforts being directed to the material after it reaches the track. Such a dearth of important information as pertains to service stresses in steel rails is probably without a parallel in the history of the materials of construction.

*In a paper on rail failures in "Engineering News," Oct. 17, 1912, Robert Job noted that the company with which he was affiliated had gathered data throughout the country on transverse fissures. His findings (p. 711) corroborate Mr. Howard's, except he always found decided porosity in the vicinity of the nucleus.—Ed.

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Diesel-Electric Motor Cars on the Swedish State Rys. have been in use for about a year past. Two such cars were built. The power equipment of each car is a 75-hp. Diesel engine running at 700 r.p.m., driving a direct-current dynamo of 50 kw. producing 440-volt current. Two 30-hp. motors are connected to the two main or driving axles, although a third axle is fitted under the machinery compartment, which is at the extreme end of the car. The Diesel engine is a four-stroke machine with six cylinders and eight compressor cylinders. Besides driving its own fuel pumps, etc., the engine also drives a small compressor for the air brakes. The engine is started with compressed air stored in steel containers. The engine exhaust goes through a muffler under the car and then to an exhaust pipe over the roof. The cooling water is taken from a tank on the ceiling of the baggage-room (just behind the engine compartment) and after going through the engine is carried through a copper radiator on the roof, being circulated by a small pump geared to the engine. Two oil tanks in the engine room provide fuel capacity for about 800 miles of run with two trailers. The fuel consumption is stated to be about 0.8 lb. of oil per mile for the motor-car alone and about 1.2 lb. per mile for the motor-car with 30-ton trailer, at an average speed of 20 to 30 miles per hour. The car is geared for a maximum speed of 40 miles per hour and as to tractive power is designed for two 30-ton trailers, the motor-car itself weighing 36 tons. Current for illumination is supplied by a 28-cell accumulator under the car, which also furnishes current for a small motor used for shifting the governor of the Diesel engine for different speeds of car. Heating in cold weather is done by passing the circulation water of the engine through radiators in the car. The cars are said to be giving satisfactory service. They were built by the Allmänna Svenska Elektriska Aktiebolaget, of Västeras, Sweden, on the order of the Swedish State Rys., Stockholm, in 1911, and were put into service in the summer of 1912. A somewhat fuller description with some illustrations may be found in the "Organ für die Fortschritte des Eisenbahnwesens," Sept. 1, 1913.

FIELD AND OFFICE

German "Ladder" Staging

A peculiar type of erection staging for use in erecting or repairing buildings, etc., is used extensively in Germany. This is the ladder scaffold, devised by L. Altmann, of Berlin, 23 years ago, which has been applied successfully not only to small and simple work, but also to nearly every kind of large and complex building erection and repair. This staging is composed of adjustable members which are used over and over again. The "Gerüstbau Aktiengesellschaft," of Berlin, the successor to Altmann's business, keeps the parts in stock and works in such a way as to relieve the building contractor of all concern about staging; it erects, maintains and takes down the staging, and its fee includes the hire of the staging. Similar companies are organized in all other important cities in Germany, Austria and Switzerland. A few of them, besides handling the ladder staging, also do some business in pole scaffolding and in adjustable staging modified from the ladder type, but personal observation during a trip through Europe indicates that the ladder staging as here illustrated commands much the larger part of the field.

In this Altmann scaffolding, all the posts are composed of "ladders" and the horizontal and vertical braces are adjustable to the required lengths. The ladder ver-

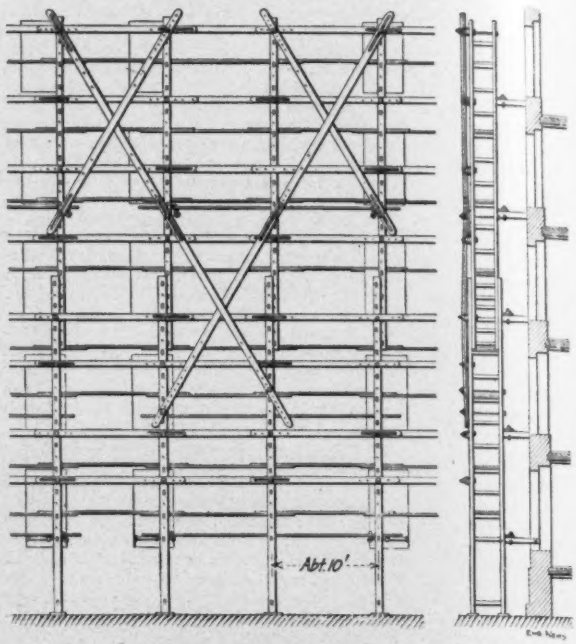


FIG. 1. TYPICAL SKETCH OF LADDER STAGING

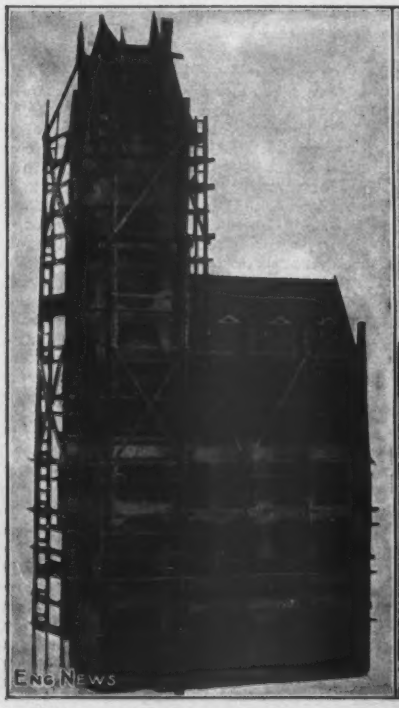


FIG. 2. A SIMPLE LADDER SCAFFOLD

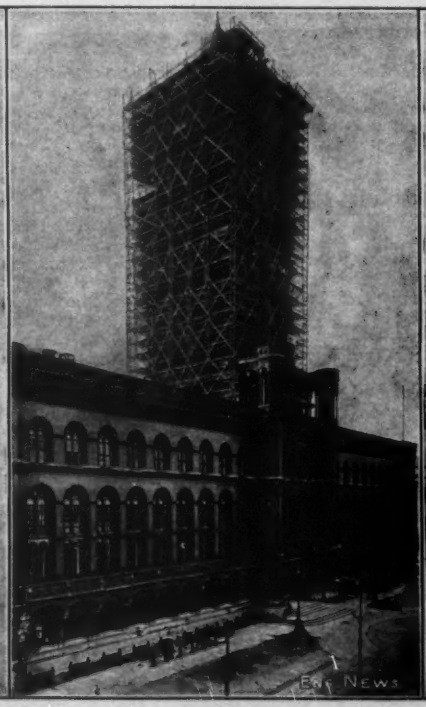


FIG. 3. STAGING AROUND TOWER OF BERLIN RATHHAUS, 1911. HEIGHT ABOVE STREET 295 FT.

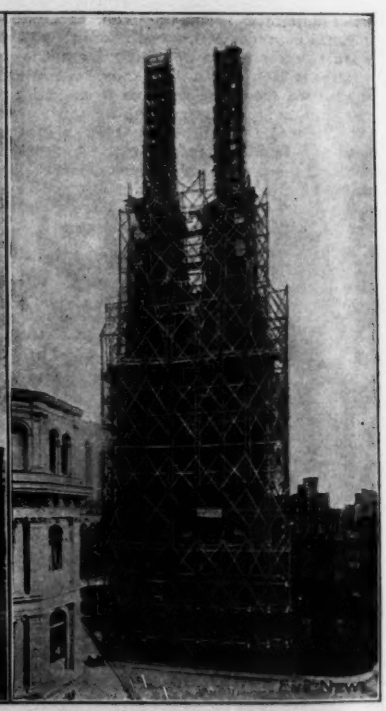


FIG. 4. TOWER-REPAIR STAGING, NIKOLAI KIRCHE, BERLIN, 280 FT. HIGH

ticals are not used for climbing (ordinary inclined ladders being set into the staging for this purpose) but are in effect two-piece posts with wooden rungs as spreaders; the utility of this construction will appear from the illustrations. For all heights of staging greater than one ladder length, the successive lengths are lapped on each other like the parts of an ordinary extension ladder, and are connected by hooks, or in case of heavy scaffolding by steel splice-plates on the sides of the ladders. Between the wooden rungs the ladder sides have 1-in. holes for temporary rungs of steel rod. Such rods are used for attaching the hooks connecting two lengths of ladder, and for supporting runway boards, beams from which tackle-blocks are hung, etc. The holes in the ladder sides are also used for the bolts which clamp the scaffold braces in place, except in the special case of braces parallel to the plane of the ladder, which are attached by hook bolts embracing the ladder side-piece.

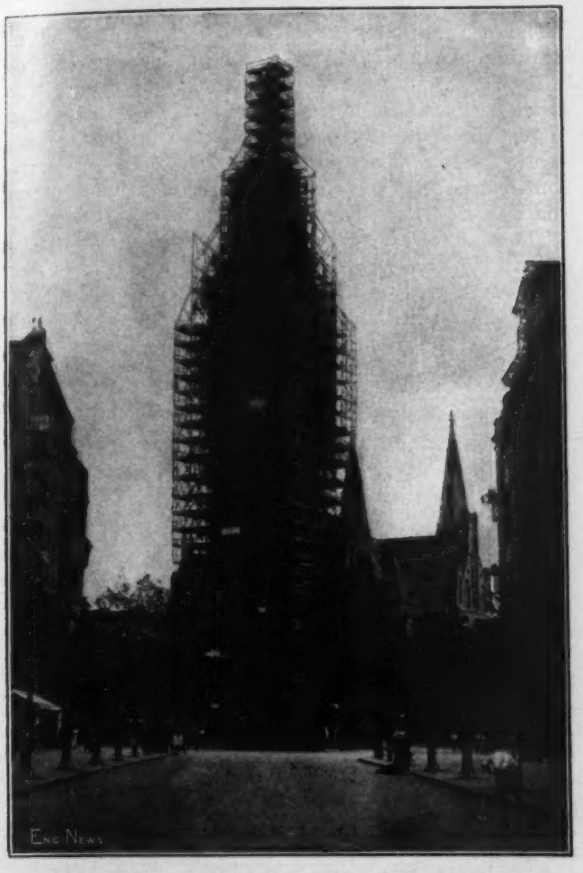


FIG. 5. STAGING AROUND APOSTEL-PAULUS KIRCHE, SCHÖNEBERG; 270 FT. HIGH

The sketch, Fig. 1, shows a simple case of ladder staging, as erected for repair work on the front of a five-story building. The ladders are set on short lengths of board as mudsills, in the position shown, and are held to the wall by spacer sticks engaging screw-jack clamps set in the window reveals (or hooked over the heads of 5½x½-in. spikes driven into the mortar joints of the wall). The horizontal and diagonal braces have a series of holes at one end and a slot at the other, taking a ⅞-in. bolt with large washers, which clamps the brace in place. The scaffold is built upward by simply laying additional lengths of ladder alongside those already in place, sliding them up till only the necessary amount of lap is left, and hooking the ladders together, then setting the wall spacers and the braces of the new tier.

Fig. 2 shows a view of a simple staging. High scaffolds are shown by Figs. 3, 4 and 5. That in Fig. 3 is a repair scaffold around the tower of the Berlin Rathaus, 195 ft. (60 m.) above the main roof, which is about 100 ft. (30 m.) above the street. The work was done in 1911. The towers of the Nikolai Kirche, Berlin, Fig. 4, are 280 ft. (85 m.) high. The Apostel-Paulus Kirche, Schöneberg, Fig. 5, is 270 ft. (82 m.) high.

In using this staging, the hoisting of material is done with rope tackle hung from sets of loading-beams laid over the tops of the ladders (i.e., resting on temporary steel rungs as mentioned). Mr. Altmann regards a load of 2500 kg. per ladder as allowable (10,000 kg. or 11 tons on a four-ladder square braced tower; for heavier lifts two ladders are used at each corner of the tower). A test load of 5200 kg. is said to have been put on a single ladder without breaking it.

Some details of the staging members are sketched in Fig. 6.

The ladder sides are half-round timbers, placed with the flat sides facing in; they are made from round sticks of slow-growth straight fir, sawn down the middle; the two halves of a log are not used for the same ladder, to avoid twisting. The sizes are: for heavy ladders, 12 cm. (5 in.) butt diameter and 8 cm. (3 in.) point diameter; for light ladders 8 cm. and 5 cm. (3 in. and 2 in.). The ladder width is 50 cm. (20 in.) in the clear, except for the upper sections of light scaffolds, where ladders 19 in. outside width are used (with flat sides facing outward), to fit into the lower section. The rungs are 1⅝x⅞-in. (2x4 cm.).

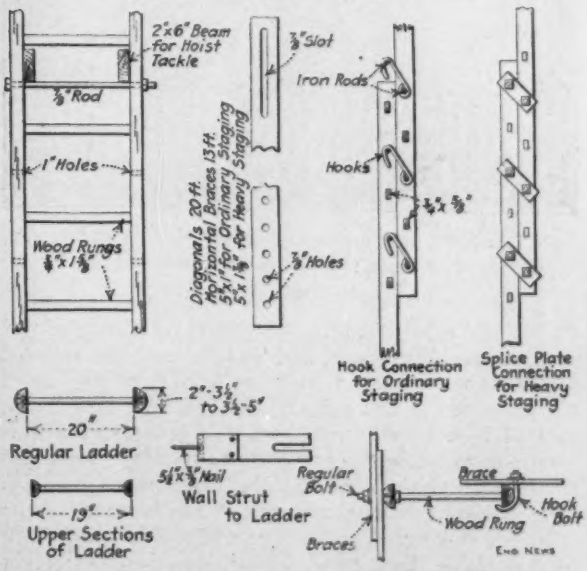


FIG. 6. TYPICAL DETAILS OF ALTMANN LADDER SCAFFOLDS

The horizontal and diagonal bracing consists of 5x1-in. (2½x12 cm.) boards, or for heavy scaffolds 5x1½-in. boards, made in lengths of 13 to 20 ft. At one end they

have a series of 1-in. holes for the connecting bolts, and at the other end a long 1-in. slot, giving complete adjustment to any panel-length.

Of the various interesting special applications of this staging system, the view, Fig. 7, is given of a scaffold with which the brick tank-tower at West End, Charlottenburg was built. The tower is 16 m. (52 ft.) in diameter. The staging had an outside diameter of 22 m.

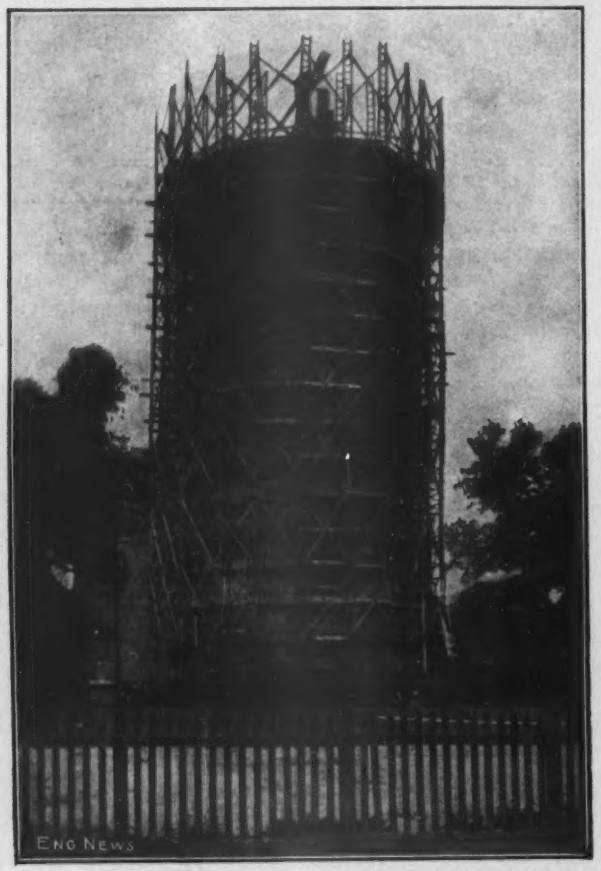


FIG. 7. ERECTION STAGING OF WEST END WATERTOWER, CHARLOTTENBURG; ENTIRE BRICKWORK LAID UP FROM THIS STAGING

72 ft.) and a height of 73 m. (240 ft.). It was erected as a free-standing frame, and was made of two rings of ladders, 2 m. apart, the inner one 1 m. from the line of the tower wall. The ladders were set with their width parallel to the wall, and instead of being spaced uniformly in each ring they were set as groups of rectangular towers, which simplified the bracing and made it more efficient. All the masonry of the tower was built from this staging. These ladder scaffolds have also been used as inside staging and centering, as in constructing reinforced-concrete floors and in building the stone-vaulted ceiling of a church.

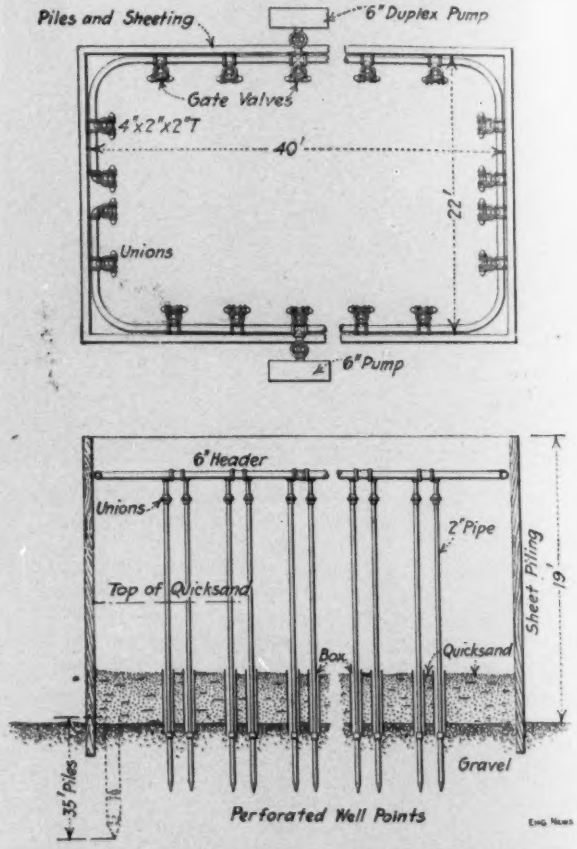
The cost of the ladder staging varies with the case in hand. To give an idea of the cost, it may be stated that the staging shown in Fig. 2 cost about $30, including the hire for three weeks' use; the charge for the staging of the Apostel-Paulus Kirche, Fig. 5, was $2250. The fee for the staging of the West End watertower, Fig. 7, was $1000, but this scaffold stood 15 months before it was taken down.

Excavating a Bridge Abutment Foundation Through Quicksand

BY FRANK I. BARRETT*

The accompanying illustrations show a method of handling quicksand where the processes of freezing or ballasting would be too expensive to undertake. The writer lays no claim to the invention of this process; but having employed it with great success in dealing with an extremely difficult piece of work he offers a description in hope that the method may be of value to others who may be called upon to deal with a similar problem.

The work, of which the writer was in charge, consisted in building some concrete bridge abutments, to rest on piles, 35 ft. below a river bottom. Just above the river bed 8 ft. of quicksand was encountered, through which it was necessary to excavate to reach the desired foundation grade. Through this the piling had to be driven



A METHOD OF EXCAVATING A FOUNDATION PIT THROUGH QUICKSAND

with a follower and by means of a water jet. The opening for the concrete abutment was 22x40 ft.

After the piles and outside sheeting had been driven the excavation pit was encircled, 19 ft. above grade, with a 6-in. pipe header, fitted with T-joints and valves spaced from 3 to 5 ft. apart, or nearer, according to the varying water conditions in different parts of the pit. To these T-joints were connected, through 2-in. pipes, 60-

*J. G. White Engineering Co., Parr Shoals, South Carolina.

mesh well-points, 3 to 4 ft. long, which were driven about 6 in. below grade. Especial care was taken to make all pipe joints air-tight.

The header pipe was connected by means of a gate valve to two 6-in. duplex pumps, one of which was held in reserve for use in case of breakdowns or the encountering of unexpectedly large amounts of water. All piping was boxed to facilitate the removal of the well joints and points. A vacuum was constantly maintained to insure proper suction and to prevent the quicksand from ever backing up in the pit.

The best kind of pump for the purpose is an outside-packed pump. A large supply of extra valves, stems, etc., should be kept on hand for use in an emergency.

To illustrate the effectiveness of this method it is of interest to note that 9 hours after the pumps were started the pit was dry and men were excavating in it. After 12 hours of excavation the pit was ready for concrete. Before the pumping was tried the bottom of the pit was so soft that a man could not stand in it, and water boiled up under the sheeting which had been driven 12 ft. below the top of the quicksand.

After 20 years' experience in excavating in soft bottom, the writer can say that the method above described is the cheapest and most satisfactory under such conditions as met with in this piece of work.

Unloading Earth from Cars by Sluicing

By J. C. Lathrop*

The water jet has been used for numerous engineering purposes, such as driving piles, placer mining, building earth-fill dams in mountainous or hilly regions, etc., and it has been applied recently as a novel method of unloading earth from railway cars and sluicing it into a fill.†

The writer recently had occasion to make a fill for the Northern Ohio Traction & Light Co., of Akron, Ohio, amounting to 10,000 cu.yd., in a location where all the material had to be delivered in cars. The cost of unloading these cars by hand and transporting the material into its final position with either slip scrapers or wheel scrapers seemed so excessive that the following method of handling by water jets was adopted.

The material consisted of cinders from various power plants and sand and gravel strippings from gravel banks, and all was ordered shipped in hopper-bottom cars. The fill was located within 400 or 500 ft. of a canal, and a centrifugal pump directly connected to a 20-hp. 500-volt d.c. motor was installed. A 4-in. pipe line was run from this pump to the dump and a dozen or more hose connections with gate valves were provided, about 100 ft. of common 2½-in. fire hose being used.

The material was delivered on cars on the railway siding adjacent to the fill, and galvanized-iron chutes were placed under the hoppers of these cars. Then the bottom gates were opened, and the nozzle was forced from the top of the car through the material, and water poured in until the water acquired sufficient head to begin washing the material into the chute. After this it was only necessary for the operator to keep sufficient material washed into the chute to keep it running uniformly full.

By this method it was found that the average carload of sand could be unloaded by two men in about two hours and deposited in any position within 150 ft. of the car. Possibly the cheapest and quickest method was to fill the car nearly full of water before opening the gates, as less water was required, i.e., the water easily carried a larger percentage of solid matter. More difficulty was experienced with the cinders than with the sand or loam, as the water jet did not seem to have its full effect, but the average car (40 cu.yd.) could be unloaded in from three to four hours.

The advantages of this system were four-fold: (1) economy in unloading and depositing. (2) The material deposited was thoroughly compact and no settlement need be apprehended. (3) The ease with which cars could be unloaded enabled a larger amount of material to be handled in a given time, thus obviating any delay in other construction work which was proceeding at the same time. (4) The scarcity of labor in this vicinity made it almost impossible to secure enough men to unload these cars by hand.

The accompanying table gives the time and cost of unloading cars (containing approximately the same amount of material) by hand and by the water jet. This table is based upon tests of individual cars, as a complete record of this work was not kept, but sufficient data were collected to make this estimate reasonably safe.

COMPARATIVE COST OF UNLOADING MATERIAL AND MAKING FILL BY WATER JETS AND BY SCRAPERS

(A) Unloading 10,000 Yd. (or 250 Cars) of Material by the Water-Jet Method	
1000 hours labor at 20c.	$200
Labor laying and removing pipe line, making electrical connections, setting pump and motor and removing same	225
Depreciation on plant, assumed at	100
1000 hp.-hr. at 2c.	20
Total (5.45c. per yd.)	$545
(B) Unloading and Spreading 10,000 Yd. (or 250 Cars) of Material with Shovels and Scrapers	
5000 hours labor at 20c.	$1000
1600 hours team and driver at 60c.	960
Total (19.6c. per cu.yd.)	$1960

Investigation of Existing Engineering Structures*

By Horace R. Thayer†

Probably no more difficult, unpleasant or thankless task confronts an engineer than the examination and report on a structure of doubtful safety.

The first step in such an undertaking is to obtain the complete dimensions, cross-sections and details of the entire structure. Sometimes these data may be found on the contract plans. These must be used with very great care, however, as it is rare that some changes are not made either at time of erection or in subsequent use.

The character of the material may appear on plans or in the records. Several pieces may be cut out to be tested, or perhaps a visual examination will determine a good deal. The former is the approved method of ascertaining if steel has been injured by fire or accident, while the latter might be of assistance in the case of wood or cast iron. It is extremely important to note the deterioration caused by rot, rust and wear due to traffic. One trouble with steel is that its overload is hard to detect by an examination unless stresses exceed the elastic limit. Workmanship must be determined by eye.

*Northern Ohio Traction & Light Co., Akron, Ohio.

†The use of hydraulic jets on a dipper dredge for the purpose of leveling the spoil bank and forming it into a levee was described in "Engineering News" of July 31, 1913.—Editor.

*Abstract from a paper entitled "Historic Failures of Engineering Structures," read before the Engineers' Society of Western Pennsylvania, May 6, 1913, and published in the June "Proceedings" of that society.

†Assistant Professor of Structural Design, Carnegie Institute of Technology, Pittsburgh, Penn.

Finally, we must estimate live loads, compute maximum unit stresses in weakest part of each member, and compare results with those allowable by some standard specifications. Before rendering a definite decision, we should consider:

(1) What possibility is there of an increase of loads during future life of the structure? It is quite possible that it might be all right for present conditions but without reserve capacity. In this case the structure should be passed conditionally.

(2) Would some special weakness exist under extraordinary loads? It may be wise to strengthen that part for the sake of the additional security.

(3) Secondary stresses need not be included for designs in accordance with modern practice. But for long members and eccentric loads secondary stresses should be computed, especially for columns. If found to be excessive, say above 15% of the principal stress, a corresponding reduction in allowable principal stress must be made. We believe that the present tendency is toward the much more logical method of computing secondary stresses and increasing in a like ratio allowable values.

(4) Assistance of parts other than those usually taken as carrying the load, is to be assumed with a great deal of caution. For example, rails, guard rails, and guard timbers will do much to assist a short, weak I-beam span; but if they are to be figured on, splices must be watched and the trackmen prevented from pulling them up for repairs at a time when the full load is coming on.

(5) Standard specifications have been evolved as a result of the failures and successes of the past and may generally be taken as a safe and dependable guide. For example, the usual clause prohibiting welded joints for members other than counters and wind laterals is to prevent accidents like that at Bussey Bridge.*

(6) Particularly to be emphasized are the following points:

(a) Precautions to avoid possible loss of life by fire in a building. Not only should the steelwork be protected as specified, but guard as well against inter-room communication and the exposure to fire.

(b) Provision for wind pressures all the way through the structure.

(c) Fastenings of each part so that its separation from the remainder can be accomplished only by the rupture of the fastening.

(d) Support of long compression members at frequent intervals.

(e) Thorough bracing, especially in localities where high winds or earthquakes may be expected.

(7) It might seem that the margin between an ultimate strength of 60,000 lb. per sq.in. and an allowable value of 16,000 lb. per sq.in. such as is employed in buildings, is excessive. First, however, let us consider that the structure would be ruined by 35,000 lb. per sq.in., or more probably 25,000, for practical conditions with full-sized pieces. When we come to consider eccentric stresses, overloads, etc., we find our margin nearly exhausted.

As a general rule we suggest:

For good designs allow 10% excess of stress above specifications; 10 to 20% overload should receive constant watching; 20 to 40% is dangerous; above 40% the structure must be replaced at once.

For poor designs, compute secondary stresses and permit totals to exceed above percentage values by 15. For worn, corroded or injured material, estimate or determine by testing, its strength as a percentage of its original strength, care being taken not to overestimate. Original allowable values multiplied by the percentages give our standards for the particular case.

*"Engineering News," Vol. 17, p. 181.

A River Ferry as a Stream-Gaging Station

By W. C. Sawyer*

The various contributions in Engineering News several months ago seemingly about exhausted the subject of current-propelled ferryboats. But an unusual use of these facilities was resorted to on the John Day River in Oregon by the writer while hydrographer for the U. S. Geological Survey, and a brief account may be of passing interest.

On the reconnaissance trip along this river for the location of gaging stations, a set of meter measurements was made from one of these current ferries. For each reading point, the boat was held with a pole and the current meter let down from the gang-plank which was run out as far as possible over the edge of the boat (Fig. 1). The meter was so far from the boat and this was of such light draft, that there was little interference with the normal current; the resultant discharge computed from these readings plotted well on the curve found from later measurements of the free stream.

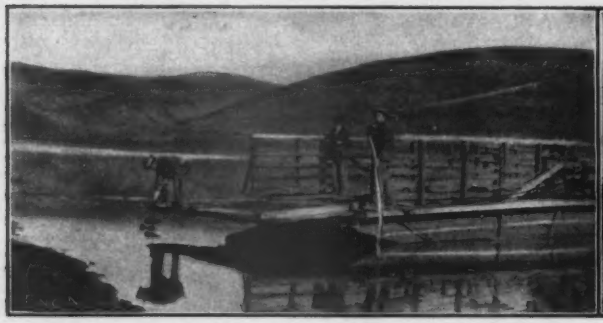


Fig. 1. Reconnaissance Gaging from a River Ferry

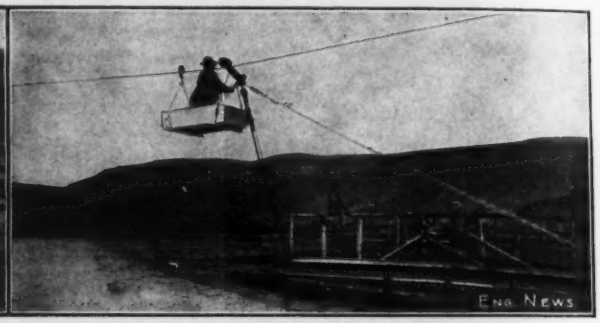


Fig. 2. Gaging-Car on Ferry Cable

The river section below the cable proved a good one for gaging, and to avoid the expense of a new cable for the station, a gaging car was suspended from the ferry cable with snatch blocks. However, precaution had to be taken to avoid interference with the ferry service. A short line, with special tightening lever, was thrown over the ferry cable (beyond the traveler when it came along) and the ends attached to one end of the car. By working the lever the cable was tightened and one end of the car lifted so that the block could be shifted and the traveler of the ferryboat run along. Putting back the first snatch block and shifting the lifting line to the other end of the car enabled the traveler to be passed by (Fig. 2). Fortunately, the ferry trips were not so numerous that these slack-wire gymnastics had to be repeated very often during a single day's gaging.

The ferry itself was operated with equal facility in either direction; lee boards were let down on the upstream side and the lines to the traveler hauled in so that the boat hung from the cable at a small angle with the perpendicular to the direction of current.

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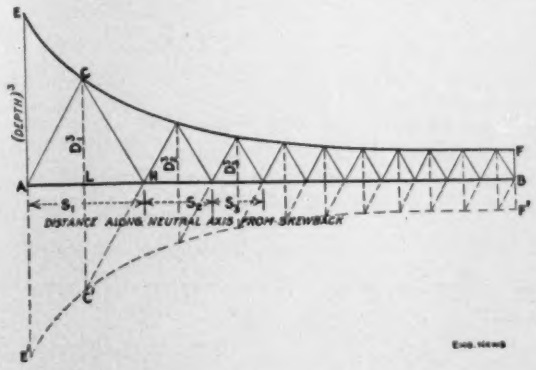
Graphical Method of Dividing Neutral Axis in Concrete Arch Design

By T. A. Smith*

In calculating the stresses in concrete arches it is customary to divide the neutral axis into sections such that the ratio of the length of each section to the cube of the depth at its center is a constant. Thus, if S represents the length of any section and D the radial depth at its center, the lengths S are made such that $\frac{S}{D^3}$ is a constant for all the sections.

The following is a graphical method for making a division of the neutral axis that will satisfy this condition:

Draw line AB in the accompanying figure to any convenient scale equal in length to one-half the neutral axis of the arch ring. The curve EF is drawn through points



whose ordinates are the values D^3 and whose abscissas are the corresponding distances along the neutral axis from the skewback. Assume the length AH, erect perpendicular LC at its center and draw AC and CH, then continue to draw lines parallel alternately to AC and CH as shown in the figure. Only three or four trials will usually be required to divide the line AB into the desired number of divisions. The base of each triangle thus formed corresponds to S and its altitude to D^3. Since all the triangles are similar by construction, the term $\frac{S}{D^3}$ is constant throughout.

The above procedure may be modified somewhat by drawing a second curve $E'F'$ below AB, using the same ordinates as for EF. Having assumed AH as before, draw perpendicular CC' at its center. Then draw AC, after which diagonals and verticals may be drawn alternately making the diagonals parallel to AC. This method offers the advantage of drawing all the diagonals parallel to the same line, while in the first scheme the diagonals were drawn parallel first to one diagonal line and then to the other.

If it is desired to take account of the steel reinforcing in the arch ring the ordinates of the curve EF may be plotted for values of $(I_c + nI_s)$ instead of D^3, I_c and I_s being the moments of inertia of the concrete and steel, respectively, and n the ratio of the modulus of elasticity of steel to that of concrete.

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Handling Rails and Heavy Track Material by Machinery*

By W. E. Davin†

A large proportion of the material used in the construction and maintenance of roadway and track has been increased in size and weight until it is now a problem to load, unload, or move some of the heavier material by hand. The men are liable to be injured, especially if they are inexperienced, and the material also is likely to suffer damage. These conditions can be overcome, in a large measure, by the use of machinery in handling heavy material.

There are in use on a number of roads, machines for loading and unloading rails, frogs and switches and other heavy material. Some roads have special machines for handling material, designed and constructed at their shops. Some are for rails exclusively and others are designed for general use. For the latter, a locomotive crane that will handle all kinds of track material and can be moved to any point on short notice, is the most satisfactory machine. Its boom should be 40 or 50 ft. long, with a removable section to adapt it to special work.

In unloading new rails and distributing them along the track for renewals, a competent operator can lift the rails out of the car and set them at the side of the track, practically in location where they are to be used, without stopping a train, moving along very slowly. The amount of labor required in connection with unloading rail with machine will be: 1 man at each end of rail in the car, 1 man to hook on, and 2 men on the ground to land rail at the proper location. In this way the danger of causing surface or line kinks in the rails is eliminated.

With little additional expense a hoisting magnet can be attached to the crane, and scrap loaded or unloaded without laborers. Rails also can be loaded and unloaded with the magnet.

Heavy frogs and track crossings sometimes are shipped in high-side gondola cars, and all the men that can get hold cannot lift them out of the car. With machinery available it is only a matter of a few minutes, with only one or two men.

In handling ties and switch timbers, a locomotive crane will result in a great saving of labor. Ties can be unloaded from open cars in large bunches at one lift, if the loading is properly arranged. Where it is necessary to load old ties they should be piled with a sleeper or sill at one end to provide for placing the chain, and all the ties should be laid parallel. The results accomplished in this class of work are very satisfactory.

For loading, unloading, handling and placing heavy cast-iron culvert pipe, a crane is very necessary and the work can be done for about half the cost of hand work. For moving or setting telegraph, telephone or other poles, the use of a crane will result in a great saving.

The extensive use of signals now requires a large amount of work in setting foundations, signal masts, bracket poles and signal bridges, and heavy interlocking machines. The work is sometimes done by hand, when a crane would have handled the work with 75% less cost.

When a track crossing in a congested terminal is required to be renewed, there frequently is no room to put the crossing together in the ground. It is assembled on a car at some convenient siding and the car is then moved to the point where it is to be used. The crane lifts the old crossing out of place, sets the new crossing into place, loads the old crossing and the work is completed in a remarkably short time at a great saving of time and delay to traffic.

In construction work, where steam-shovel tracks are to be shifted, a crane car can lift the tracks and shift the line. On fills and where tracks are being elevated the locomotive crane is indispensable.

⌘

Roller Skating for business purposes instead of amusement is a rather novel idea noted in a description of the new car-house of the Union Street Ry., at New Bedford, Mass., in the "Electric Railway Journal." The storeroom is of very large size and the workmen employed in it wear roller skates in order to save time in making their continual trips from point to point. It is stated that the men find no difficulty in using the ladders which give access to the upper shelves and bins.

*Abstract of a paper in the June number of the "Maintenance-of-Way Bulletin," issued by the Roadmasters and Maintenance-of-Way Association, at Sterling, Ill.

†Supervisor, Pittsburgh & Lake Erie R.R., McKees Rocks, Penn.

Cost Data on Blueprinting

By Frank H. Jones*

Actual experience in the management of the blueprinting department maintained by a large Eastern railroad afforded an opportunity to secure the following cost data, which may prove of interest and value to those who have similar installations under consideration.

Fixed overhead charges, such as rent of space, lighting and heating, have been neglected in determining the cost of printing for periods of one typical month each. The given unit price is based on the cost of power, material, and labor. Each department using the printing room is charged a share of the total cost of maintenance as figured from the paper and cloth actually used by them.

A 60-in. Everett-McAdam blueprinting machine, complete with lights and motor, was installed in 1908, the initial cost being $750, and the cost of wiring and other necessary changes in the room was $25. The average life of each mercury-arc lamp under ordinary conditions is about 18 months. The cost per lamp for replacing is $16, complete. Through carelessness the large glass cylinder of the machine has been broken once and replaced at a cost of $75. The total cost of renewal and maintenance of the machine in four years of constant service has been about 20% of the initial cost.

The average amount of electricity used in running off from 12,000 to 18,000 sq.ft. of paper and cloth blueprints and Van Dyke prints is estimated at about 200 to 300 kw. hr., and is furnished by the terminal company at 11c. per kw. hour.

Two men, one at $50 per month, for printing, management, and making reports, and one at $6 or $8 per week for washing and cutting, can handle about 15,000 to 25,000 sq.ft. of the average run of printing per month, including cloth, white and Van Dyke prints. Seven to eight hours per day and three or four hours on Saturday constitute the basis of time. One man, who is a hustler, can print, wash and trim from 8000 to 12,000 sq.ft. per month, the basis of time being seven hours per day.

The cost of blueprint paper and other process-printing stock is figured on the monthly statements at an average of 0.4c. per sq.ft. This includes the average run of all kinds of process-print stock. Quotations on coated paper from a standard dealer are:

50-yd. roll 24-in. medium paper	$1.10
50-yd. roll 30-in. medium paper	1.20
50-yd. roll 36-in. medium paper	1.30
50-yd. roll 42-in. medium paper	1.40
50 yd. roll 54-in. medium paper	2.25
10-yd. roll 30-in. cloth	2.00

Monthly statements showing the cost of operating the blueprinting department for typical months and under various conditions are given herewith:

November, 1911		February, 1913	
Sq.ft. paper used	14,300	Sq.ft. paper used	9427
Sq.ft. on orders	12,920	Sq.ft. on orders	6788
Cost of paper	$57.20	Cost of paper	$37.71
Cost of power	29.81	Cost of power	26.73
Cost of labor	48.71	Cost of labor	67.80
Total cost	135.72	Total cost	132.24
Cost per sq.ft.	0.0103	Cost per sq.ft.	0.014
Waste	10%	Waste	28%
October, 1912		**March, 1913**	
Sq.ft. paper used	9901	Sq.ft. paper used	25,896
Sq.ft. on orders	8327	Sq.ft. on orders	22,027
Cost of paper	$39.64	Cost of paper	$103.58
Cost of power	23.31	Cost of power	33.00
Cost of labor	75.05	Cost of labor	75.45
Total cost	138.00	Total cost	212.03
Cost per sq.ft.	0.014	Cost per sq.ft.	0.0095
Waste	16%	Waste	15.3%

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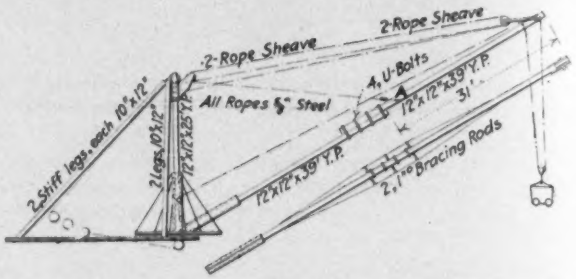
Another Rigging for a Derrick

A derrick rigging involving a single connection of the becket line to the boom, a little beyond the center of the latter, was observed by J. L. Southworth, Assistant Engineer, New York Barge Canal, and is illustrated in the accompanying sketch sent to us by him. We assume that the method applies only to spliced-boom derricks.

In Engineering News, June 26, we published the sketch of a certain derrick whose boom broke. With this



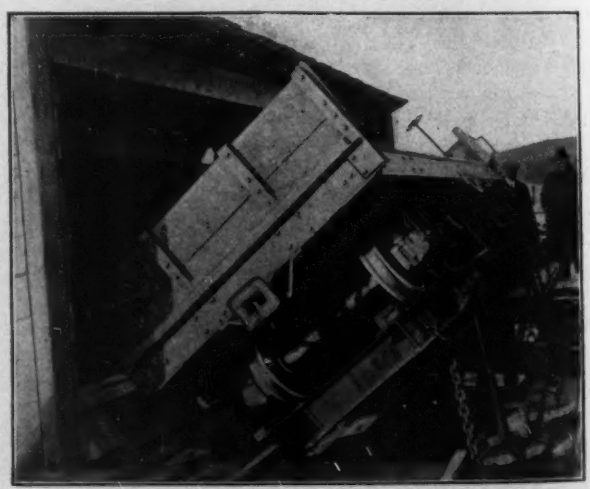
rigging the becket line was fastened to the boom at several points. We also invited discussion upon the subject of derrick rigging.

Mr. Southworth claims that the method of rigging shown in his sketch "allows the boom more freedom for vibration, thereby lessening the chances of the end snapping off, in the event of the boom being dropped and suddenly caught."

A Platform for Dumping Quarry Cars

Cars for carrying stone from the quarry to the crusher should be as low in height as possible, particularly if they are to be loaded by hand. They should also be so constructed as to dump instantaneously and automatically upon arriving at the crusher, both to save time in unloading and to save the additional cost of unloading by hand. For this kind of work several cars have been designed which involve two underframes; but this duplication of parts greatly increases the cost of the car.

The accompanying photographic view shows the design and the operation of a car and dumping system



The Dumping Platform in Operation

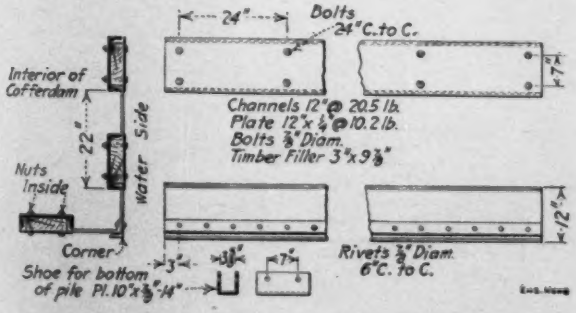
devised by the Orenstein-Arthur Koppel Co., of Pittsburgh, Penn., which is claimed to involve a lower first cost, and to make unloading cheaper, than any other type of equipment for a like purpose. As shown in the illustration, the cars are very low double-truck flat-cars, having a floor space 20x6 ft. 5 in., 2 ft. 8⅝ in. above the rails.

A platform, hinged at one side and supported on the other by two air cylinders, is installed at the crusher. Upon its arrival at this point the car runs upon this platform, and a catch automatically engages the side of the car. By admitting air into the cylinders, the platform and car floor are tilted to an angle of 45 degrees, dumping the load into the crusher. Releasing the air from the cylinders, after the removal of the load, causes the car to resume its normal position.

NOTES

Cinder-Concrete Wall Lining is used on the exterior walls of the new building of the Deutsches Museum, at Munich, Germany. Its purpose is to serve as insulation and also supply a base which will take nailing, etc. It is not made with ordinary ashes or cinders, but with broken tufa, from Andernach-on-the-Rhine. With this material a cement concrete is mixed 1:12 or 1:16, and used to form a 5-in. layer on the inner face of the exterior wall, the rest of the wall being stone concrete. This tufa concrete permits nails to be driven in easily, and it can be worked with tools, as was proven by sawing into it at the corner of a door jamb with an ordinary crosscut saw.

Combination Steel-and-Wood Sheetpiling—In the construction of the new bridge over the Cumberland River at Nashville, Tenn., for the Louisville & Nashville R.R., the cofferdams for the piers were made with steel-and-wood sheetpiles, of a type patented by H. M. Gould, Vice-President of the Foster-Creighton-Gould Co., of Nashville, which has the contract for the bridge. The piles are shown in the accompanying cut, and consist of 12-in. 20½-lb. steel channels set with the flanges overlapping or interlocked. Each alternate pile has on the inside a 3-in. timber 9⅞ in. wide, covered with a ¼-in. steel plate 12 in. wide, as shown. The timber and plate are secured in place by ⅞-in. bolts through the web of the channel. The flanges of the two adjacent channels lap over the flanges of the combination pile. They bear against the sides of the timber, while the projecting sides of the steel

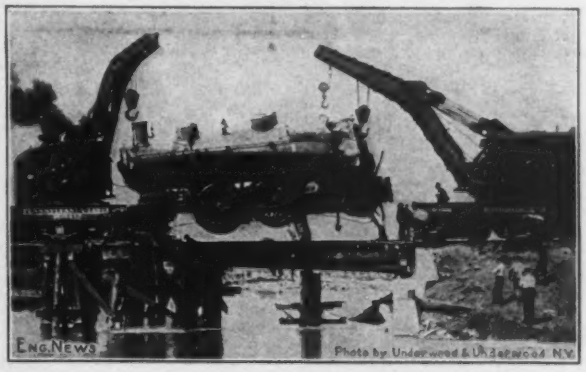


STEEL SHEETPILING WITH FILLER TIMBER
H. M. GOULD, NASHVILLE, TENN.; INVENTOR

plate serve to hold the piles in place. The corner of the cofferdam is made by fitting two channels at right angles and riveting them together, as shown.

The moment of inertia for the 12-in. channel-and-plate pile (not counting the timber filler) is 18.6, and the weight of shapes per sq.ft. of cofferdam is 28 lb. For 15-in. piles, the figures are 33.9 and 34.5 lb., respectively.

Engine Long Submerged—In the great March floods (Mar. 24-28, 1913) a Pennsylvania passenger locomotive went into the Mad River at East Liberty, Ohio, where a bridge was washed out. Traffic across the gap was restored in a month, but the engine was not hauled out of the water until nearly four months later. The view below was taken Aug. 14; two wrecking cranes are lifting the locomotive out of the river and setting it on the trestle.



HOISTING LOCOMOTIVE OUT OF THE MAD RIVER AFTER 4½ MONTHS' SUBMERGENCE

Plumb Line Target—The patentee of the plumb line target described in our issue of Aug. 21, p. 365, has this to say in regard to our suggestion that the wind might be an obstacle in centering the bob with target attached:

Before I applied for a patent on this device, I tried out the disk in different ways, and I found that the proper method of using the device was to hold the disk and string against the forefinger, so that the man at the transit would get a full view of it, and could readily find the plumb-bob line. This is the way the target should actually be used. I found that when this method was applied, it had a tendency to steady the string with the plumb bob at the end of it. Under these conditions, I can see no grounds for your objection.

Manual Signals for Field Engineers—The following contribution to this subject is made by J. V. Rockwell, Civil Engineer, U. S. N., Washington, D. C.:

Referring to the manual signals for field engineers described in your issues of May 22 and Aug. 21, 1913: it is over 10 years since I was engaged in railway work (on the Chicago & Northwestern Ry.), but at that time there appeared to be in general use signals almost identical with "A" to "G" inclusive and "J" of those shown by Mr. Beard in your issue of Aug. 21, 1913.

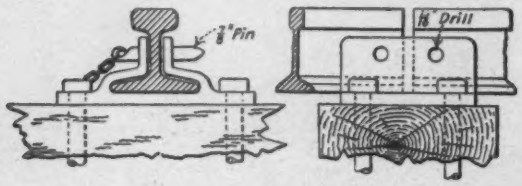
For transmitting numbers it was customary to face toward the person with whom communication was desired, and go through motions of writing the figure on an imaginary blackboard somewhat as shown in the attached sketch, which illustrates the method of signaling the figure 3. This was comparatively simple, required only one hand and did not necessitate memorizing any semaphore code, as would be necessary with the systems illustrated in "Engineering News"; nor would it be necessary to step out from behind the instrument in sending; and one hand would serve. Of course, to the receiver of the number the figure appears backward or as it would be seen in a mirror. These signals appeared to be a matter of common knowledge; a new man coming into the party would easily pick them up by association; there were no printed forms or instructions.

MANUAL SIGNALS FOR FIELD ENGINEERS

Steam Shovel Track Connection—Every shovel man knows that much time is needlessly lost in moving up. This loss is sometimes due to the poor organization of the crew, but more often to derailment and other delays due to soft ground and poor track laying. Many methods have been devised for cutting down these accidents by the introduction of various devices for connecting the track ends.

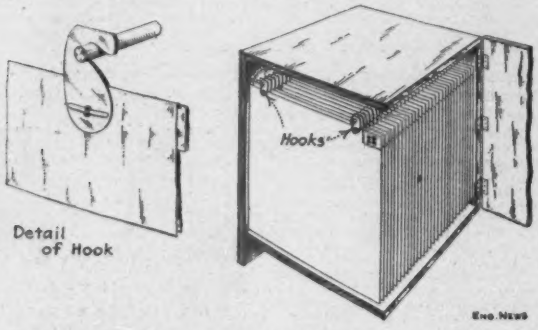
The most common method is the ordinary splice bar, which holds the rails together by means of a pair of pins or bolts slipped through holes bored in the rail ends and through each end of the bar. Another device is a pair of angles mounted on a plate and bolted to the tie. A better device, however, is a rail chair. It consists of a steel casting which fits loosely over the end of the rail, its length corresponding to the width of the tie, i.e., 8 in. The casting is bolted to the tie as shown, and is fitted with pins chained to the castings in order to prevent loss.

This device has several important advantages over other devices. One of the chief causes of derailment is the sideways rolling of the rail. This is guarded against by the vertical flanges which fit close to the rail under the rail flange. This affords far greater rigidity than any other method. In shovel work the rails are often laid on uneven or soft ground, consequently the end of either rail is apt to be unsupported, as the tie will usually come under one end



more than the other. Hence, the unsupported rail will tilt when the shovel wheel strikes the joint. The device described prevents this as it is firmly bolted to the tie. It saves time in laying track and insures a connection that the wheels will pass over without danger of derailment.—[From the "Excavating Engineer," July, 1913.]

Hook for Drawings in Vertical Filing Cases—In filing blueprints and drawings a very general practice is to fasten them together in sets by means of clamps or clasps of various kinds and suspend them in vertical filing cases. A simple method of fastening, shown in the accompanying cut, consists in the use of thin flat metal hooks, the lower part of which is split so as to receive the group of prints, and is perforated to receive an eyelet or staple which binds the prints together. The upper part is hooked over a rod in the top of the filing case, there being two hooks to each set of prints, as shown.



HOOK AND FASTENING FOR DRAWINGS IN VERTICAL FILING CASES

If a cover sheet is used, this can have an index or filing number in the upper right-hand corner. The cut shows the general arrangement and also the hook in detail. The device is manufactured by the Ideal Specialty Co., of Detroit, Mich.

Calculating and Adding Machines are used quite extensively in engineering and commercial offices, and a modified design recently introduced is said to contain important improvements tending to accuracy in operation. These improvements are locking devices intended particularly to reduce the liability of error on the part of the operator and thus guard against mistakes and carelessness. In a machine having rows of keys there is the liability of accidentally touching two keys at once, and partially depressing a key adjacent to the one intended. The movement may be sufficient to cause the unintentional adding of a number in another column. To prevent this, in the new machine each key is made in two parts and cannot be depressed except when struck squarely on the top.

In order to have the mechanism perform its functions properly and make the correct additions, it is necessary that each key, when struck, shall have its full travel on both the upward and downward strokes. But an inexperienced or careless operator may make a slurred or partial stroke to a key, causing it to add a wrong amount. To eliminate this liability of error, the mechanism is so interlocked that if a key does not make its full downward stroke, all the keys in the other columns are locked, and the numeral wheel in the column where the error is made shows a figure indicating to the operator which key was improperly struck. If this occurs while performing addition, and many numbers have been added, the mistake is corrected by completing the unfinished stroke of the key. Then a release button is pressed and the operator proceeds with his work. This avoids the necessity of having to begin the work anew.

Should a key be struck a second time before it has completed its upward or return stroke, it will not be depressed, but will be locked by a device which prevents reversal until the full upward stroke has been completed and the key returned to its normal position in the keyboard. These devices not only guard against wrong operation, but notify the operator of the error and compel him to correct it before he can proceed. They thus enable the machines to be operated safely by men who had little training or experience with them. The improved machine is known as the Model E Comptometer, and is manufactured by the Felt & Tarrant Mfg. Co., of Chicago.

A Fountain Drawing Pen—Many unsuccessful attempts to manufacture a fountain drawing pen of commercial value have been made. It is now claimed that such a device has been perfected. The principle is very simple. The ink is contained in a rubber reservoir within the handle, as in the self-filling fountain pen in common use, and is fed to the blade by pressing a conveniently placed lever, which also regulates the amount of flow. Should the test of time prove the claims of the manufacturer, the Keuffel & Esser Co., the pen will prove a valuable tool in the drafting room.

An Effective Cantilever Bridge, shown in the accompanying Fig. 1 and detailed in Fig. 2, was built by a troop of Boy Scouts over the Potlatch River, Idaho, after a sketch made by Prof. D. B. Steinman, of the Department of Civil Engineering of the University of Idaho.

FIG. 1. A CANTILEVER BRIDGE BUILT BY BOY SCOUTS

The 24-ft. suspended span consists of two 6-in. logs fastened into grooved bevels at the ends of the 8-in. logs forming the cantilever arms. The anchor arms are buried under a rock fill in inclined holes dug into the banks of the river. The roadway was made by laying cross logs held in place by the longitudinal stringers shown on the roadway in Fig. 1.

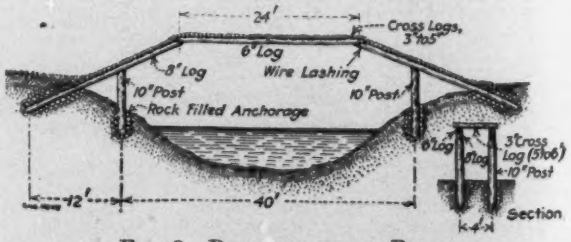


FIG. 2. DETAILS OF THE BRIDGE

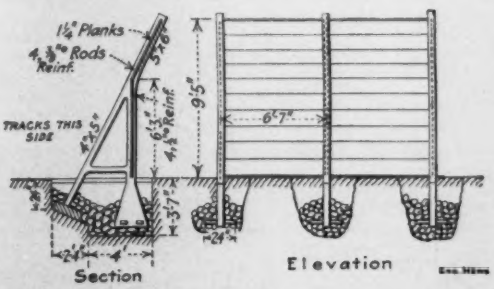
Prof. Steinman writes: "Although the bridge was undertaken merely to interest and instruct the boys, it appears to be a practical design. It withstands storm and high water and is capable of carrying pack-horses and pedestrians."

It is doubtful if any other type of bridge of equal simplicity would fulfill the requirements without employing longer or heavier timbers.

Gasoline Motor Trucks in a Railway Repair Shop are found advantageous at Nippes, near Cologne, Germany. The locomotive shop there is old, dating from 1859 though much enlarged in subsequent years. The arrangement of the plant

is such that the facilities for handling heavy material from the yard are limited. Trolleyways can be used only in certain rooms and narrow-gage railway tracks can be used only in part of the yard. The problem of handling material was solved by adopting power trucks; two gasoline trucks, each capable of carrying 2 tons and hauling a 4-ton trailer in addition, are in service at the present time. They have 12-hp. engines. The vehicles are unusually small, compact and heavy, and they are of special design, radically different in numerous respects from the design of ordinary automobile trucks. The drive is geared for speeds of 1½ and 3 miles an hour.

Snow Fences for the Italian State Railways have been built of reinforced concrete along the Termoli-Campobasso line on the east coast of the peninsula. This branch is in mountainous country subject to heavy and continuous snow fall, which fills up the cuts beyond the power of the equipment to remove. About five years ago a start was made toward the construction of snow fences along the most unprotected sections of the line, following the design shown in the accompanying cut. Since then the whole line has been so protected, with great success.



DETAIL OF SNOW FENCE ON A PART OF THE ITALIAN STATE RAILWAYS

The fence comprises reinforced-concrete standards spaced 6 ft. 7 in. c. to c., with an intervening fence made up of 3-in. pine plank, fitting into grooves in the standards. Each standard is of the size and slope shown and is founded on rock ballast filled into a pit dug for the purpose. The reinforcement of the posts is made up of four round rods tied together with ⅛-in. wire.

The fence is designed to resist safely a uniform horizontal thrust of 20 lb. per sq.ft. or a concentrated horizontal thrust of 660 lb. at the top of each section of the fence.

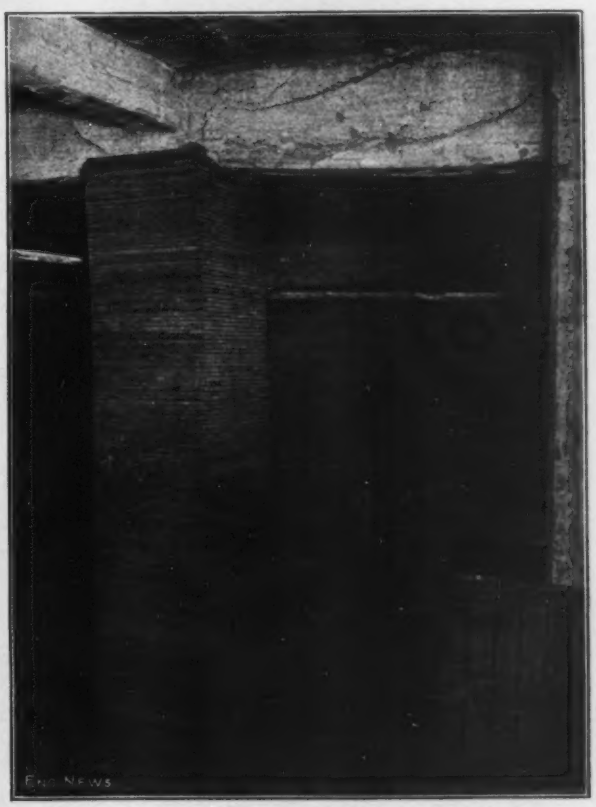
The construction is described in "Rivista Tecnica delle Ferrovie Italiane," Aug. 15.

Rates Paid for Hired Machinery—The following table is taken from the recent annual report of the Public Works Department of Boston, Mass., and the data given refer to machinery hired by the sewer service of the department for construction and repair work on the city's sewer system, most of which is done by city day labor:

Bull wheel derrick and engine	$150 to $85 per mo.
Pumping engine	$2 per day
Carson trench machine, complete	$170 per mo.
Carson trench machine, without engine	$125 and $120 per mo.
Centrifugal pump	$1.50 and $2 per day
Pulsometer	$1.25 and $1.50 per day
Electric motor	$1 per mo. per hp.
Cableway and engine complete	$170 per mo.
Hoisting engine	$75 per mo.
Boiler	$2 per day
Buckets	$1.40 per mo. each

Engineering, Administration and Incidental Expenses on $3,741,000 of contract sewer construction at Louisville, Ky., amounted to 12.07%, according to the Final Report of the Commissioners of Sewerage, January, 1910, to Mar. 13, 1913. On the 86 contracts this class of expenses ranged from 3.81% on a job costing slightly under $60,000 to 28.52% on a job costing about $27,000. For the job of highest cost ($330,000) the expenses for engineering, etc., were 10.26% of the total cost. The report mentioned contains a table which gives for each job the payment to the contractor at contract price, for extra work and for bonus; also liquidated damages charged to contractor, payments to contractor on account of claims for damages, and total payment to contractor. The table closes with expense for engineering, etc., and total cost under each contract. Percentages are given corresponding to each of the column heads. J. B. F. Breed was chief engineer of the Sewerage Commission and Harrison P. Eddy, of Boston, Mass., was consulting engineer.

The Expansive Power of Water-Soaked Wood is well illustrated by the accompanying view, taken in the basement of the Dayton, Ohio, factory of the Maxwell Motor Car Co. Just before the March-April flood of this year the pile of dash boards shown, made of oak veneered with maple, was stacked to within 1 in. of the lower face of the reinforced-concrete beam, forming part of the framing of the first floor of the plant. During the flood the basement was filled with water and the wooden plates consequently became soaked. They swelled to such an extent that they not only jammed against the girder, but in addition forced it up about 3 in. at the point of contact. The beam was cracked so seriously as to require replacing. The girder section was 12x24 in.



A WATER-SOAKED PILE OF OAK BOARDS WHICH PUSHED UP A CONCRETE FLOOR

The photograph from which the view was made was first furnished by T. B. Sellers, of the Ohio Inspection Bureau, Columbus, Ohio, to the "Quarterly" of the National Fire Protection Association, in the July, 1913, issue of which the view appeared.

Repairing a Damaged Steamship while floated by compressed air, instead of taking the vessel into dry dock, was accomplished early this year by W. W. Wotherspoon, an engineer who has had large success in the use of compressed air in raising sunken vessels. The transatlantic steamer "Uranium," 5180 tons, went ashore at Chebucto Head, Nova Scotia, on Jan. 12, and after being floated was taken to Halifax for repair. The dry-dock, however, was occupied by another steamer, and would not be available until March. To avoid the delay, the rents in the hull were patched while the damaged compartments were filled with compressed air, the ship being practically a floating caisson. Men entered the air locks and made templates for the patch plates and bolt holes, and drilled the necessary holes. The plates (with tap bolts inserted) were lowered outside the hull, and guided into place by a diver standing on a submerged platform; the bolts were entered into the proper holes, and nuts and washers applied by the men on the inside. The ship was then able to proceed to New York. The work was very similar to that done last year by the same contractor on the larger transatlantic liner "Royal George," the latter ship making a voyage to England after having been repaired in this way, as described in "Engineering News" of Aug. 28.

Welding Nickel is now practiced in many shops using nickel sheets and the like as raw material, according to a recent article in "Autogene Metallbearbeitung" (Nürnberg, Germany). By working at the proper temperature and by hammering the metal during the work, a perfect weld can be obtained. The requirements are that the surfaces to be welded must be absolutely clean and bright, that the material must be heated to a clear white, that the support on which the sheet rests must have been heated to at least 700 to 800° C., and that the working must be done with light, long-handled hammers (weighing about 1 lb.). Under these conditions the procedure is like that in ordinary welding. However, to repair flaws or seams in nickel sheets, castings or the like, the defects should be scraped clean throughout and, after heating a thin rod or wire of pure nickel held against the flaw in the flame of a high temperature torch and with a small hammer the metal driven into the flaw or porous spot and worked sufficiently to secure complete union.

A Diagram for Computing Water-Hammer Pressure

By Frank H. Carter*

The determination of the proper thickness of material for steel-pipe lines involves a consideration of water-hammer as one of the important factors. For computation of thickness of pipe for cast-iron pipe distribution systems with every line practically closed, it has been the custom to make certain arbitrary allowances of increased pressure due to water-hammer, assigning certain values according to the diameter of the pipe, as follows:

42 to 60 in.	70 lb.
36 in.	75 lb.
30 in.	80 lb.
24 in.	85 lb.
20 in.	90 lb.
16 in.	100 lb.
12 in.	110 lb.
10 to 3 in.	120 lb.

From New England Water Works Association specifications for cast-iron pipe.

In dealing with penstock pipe lines for water power, with one end open and the other end connected to water wheels, the problem of water-hammer differs from the closed distribution system in that the water-hammer probably varies from a maximum at the wheel to perhaps zero at the upper end. The law of variation has yet to be determined. In a closed water-distribution pipe system for water-supply it is assumed, and probably correctly, that the excess pressure due to water-hammer is as likely to be as great in one portion of the pipe as in another, unless there is direct evidence to the contrary; such as, for instance, proximity to standpipes for the supply to locomotives with water.

In making studies for a penstock line recently, the accompanying diagram was worked up by the writer from J. P. Frizell's formula.†

$$P_t = \frac{u}{v} \times \frac{E_w}{1 + \frac{2r}{f} \times \frac{E_w}{E_r}}$$

when

u = initial velocity of water;
v = velocity of sound in water = 4700 ft. per sec.;
r = inside radius of pipe;
f = thickness of pipe in inches;
E_w = modulus of elasticity of water = 700,000 lb. per sq.in.;
E_r = modulus of elasticity of pipe.

This formula is applicable only to long pipe lines, i.e., those whose length is over one-half the length necessary for the wave of "water-hammer," or excess pressure, to travel during the time required to close the valve whose closing causes the shock. Prof. I. P. Church* states that if the closing of this gate in seconds T is greater than the time of a wave "round trip" from gate to reservoir and back T_s, the intensity of pressure due to water-hammer will diminish as follows:

$$\frac{P_t}{P} = \frac{T_s}{T}$$

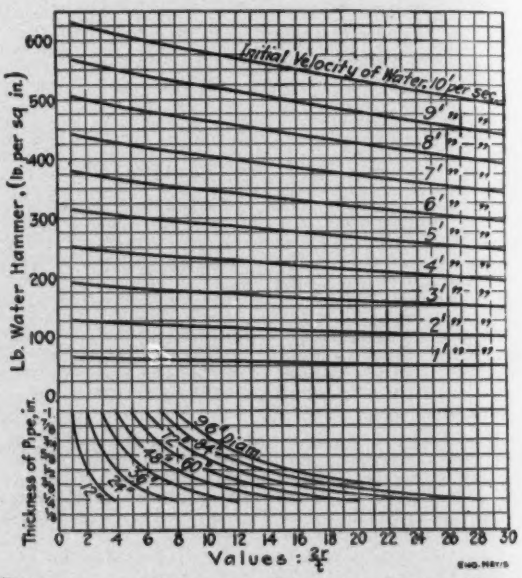
The time T_s required for a wave of compression to travel twice the length of the pipe, that is, to make the round trip is

$$T_s = \frac{2L}{V_s}$$

Where V_s = 4700 ft. per sec. approximately (velocity of sound in water).

EXAMPLES—What will the excess pressure of water hammer probably amount to at the lower end of a penstock 15,000 ft. long, whose diameter is 60 in. and whose thickness of steel is ⅝ in., the initial velocity of the water in the pipe being 6.00 ft. per sec. at the time the gate valve begins to close?

Entering the lower part of the diagram under a thickness of ⅝ in. and running along the horizontal line to the curve



A Diagram for Computing Probable Water-Hammer in Penstocks

makes 60-in. diameter, thence by the vertical line to the curve in the upper part of the diagram marked "6 ft. per sec.," we read on the left-hand scale "352 lb.," as the probable amount of excess pressure due to water-hammer, if the gate should be closed in less than $\frac{2L}{4700} = 6.4$ seconds.

Again, what excess pressure will be caused by closing a gate valve on a 60-in. line 3000 ft. long and ⅝ in. thick in five seconds, the initial velocity being assumed at 5.00 ft. per sec.?

Here $\frac{2L}{4700} = 1.28$ seconds, and reading from the diagram the water-hammer caused by closing the gate at the lower end of the pipe line in Ts or 1.28 seconds is 295 pounds.

Then from the formula of Prof. Church

$$\frac{P_t}{295} = \frac{1.28}{5} \text{ and } P_t = 115 \text{ lb.}$$

The excess pressure allowance for water-hammer therefore should be 115 lb.

*147 Magazine St., Cambridge, Mass.

†J. P. Frizell, "Transactions," Am. Soc. C. E., Vol. 39, p. 4; Terminology from Turneaure and Russell's "Public Water Supplies," 1st Ed., p. 243; 2nd Ed., p. 253.

*Hughes and Safford, "Hydraulics," p. 396; Church, "Hydraulic Motors," 1st Ed., p. 209.

EDITORIALS

One Way to Cure Bad Roads

A newspaper item from Pottsville, Penn., states that on Sept. 6 the Grand Jury at that place indicted the State Highway Commissioner, the District Superintendent of Highways, the Chief Engineer and the State Road Inspector of the district for misdemeanor in allowing several State highways in that locality to remain in an impassable condition. If this precedent were to be generally followed, it would be extremely difficult to induce responsible men to accept positions in charge of highway construction. It might even be necessary under such circumstances to follow the example of some of the counties in the South and West which have defaulted on bonds issued many years ago in aid of railways. Certain officers of these counties, who are subject to imprisonment as a result of such defaults, are said to be regularly elected with the full understanding that they are to spend their time in jail during their term of office.

We do not, of course, defend neglect of duties by those responsible for their discharge; but anyone undertaking the maintenance of a large mileage of highways in the United States today will of necessity fall far short of perfection in his performance. He will have to deal with roads more or less of which have been poorly built and poorly maintained in the past and which are being subjected to a traffic which their builders never foresaw. He will have to work with an organization in which more or less of ignorance and graft and political manipulation has been the rule. To expect perfect results under such conditions is to expect the impossible.

The American people who want good roads need not expect to see their whole highway practice revolutionized this year or next year. The "recall" of a public official may be excellent where his incompetence is well established, but to jail a road officer for every stretch of bad road is too much like the Chinese custom of beheading every local official who incurs the displeasure of a Mandarin on his inspection tours.

Protecting Towns and Cities from Blackmailing Patent Litigation

If the only patents ever issued were those covering genuine improvements in the art or industry to which they apply—improvements representing an actual advance over previous practice—it is pretty safe to say that there would be no public opposition whatever to the patent system.

Under existing conditions, however, a large proportion of the engineering profession holds a hostile attitude toward the patent system, or at least the misuses of the patent system which have become altogether too common. We refer to the exploiting of patents granted upon trifling details of this, or that, or the other article of common use, and particularly to the collection of royalties on patents of doubtful validity by pressing claims against small users who are not in a position to ably contest a patent suit.

In ninety-nine cases out of a hundred, the officials of a country town or a county or a small city know very little about patent law. They receive a notification that on some of the work under their charge, very likely built under direction of a reputable engineer, some patent has been infringed. The officials are given the choice of paying the royalty demanded or defending a suit for infringement. The most they know about patent litigation is that it is exceedingly expensive. As to the merits of the patentee's claim they know nothing. The easiest way for them out of the trouble, therefore, is to pay the royalty demanded, even though they may deem it unjust, rather than undertake the risk and expense of a patent suit.

In many such cases the engineer who has been responsible for the installation in question is blamed. Even if he is free from financial responsibility for the infringement, it is urged that he should have chosen a design that would not have interfered with anyone's patent.

Of course, if the owner of the patent in question controls a really valuable improvement in the art to which the patent relates, no one will question the justice of his demands for a royalty payment. We are not referring to patents of this class, but to patents which would not stand a fair test in a court before which the state of the art was fully sifted. Unfortunately, it is often possible for unprincipled owners of patents which would not stand such a test to collect considerable amounts in royalties through a period of years without having their actual rights tested by the court. Sufficient suits can be brought against those who do not promptly accede to the demand for royalty to have a strong moral effect upon the smaller users at least. Suits can even be sent to trial in cases where it is found that the defense is relying on a weak or ignorant attorney or is not willing to spend enough money to investigate the state of the art and reveal the weakness of the patent in question.

That the blackmailing of towns and cities by the process above briefly outlined has become a serious matter in some sections is indicated by a law just enacted by the last Iowa Legislature. This law enables the defense of a patent suit involving towns and citi s in Iowa to be undertaken by the State itself. The act is limited specifically to patents relating to highway, bridge or culvert construction; but there is no reason why it should not be extended to other matters in which patent suits may be brought against towns and cities. We see nothing in such an act in any way inimical to the rights of legitimate patentees who are willing that their patents should stand the test of thorough sifting by the courts. The law simply enables the state to assume the burden of the defense in such cases for the benefit of all the municipalities in the state instead of putting upon some one of them the whole expense of a test suit.

The High Price of Capital

It is unnecessary for us to say to engineers that money for all sorts of productive enterprises at the present time is hard to get and must be paid for at a high rate of interest. The fact has been of record for months in the financial columns of every newspaper and is a matter of common business experience.

Further, since nearly all construction work, whether carried on by corporations, cities or states, must be provided for by borrowing money through an issue of bonds, the state of the bond market is a matter of vital interest to the engineer. Not only does it have a very serious effect upon the employment of engineers, but it compels the engineer to revise many of his calculations. The question whether an enterprise will or will not pay to those who invest their money in the risky end of it, is very closely dependent upon the rate of interest, since it is that which governs the fixed charges.

It is not so many years ago that municipal or state bonds of the highest character bearing 3 to 3½ per cent. interest were readily salable. Some of the railway companies of highest financial standing were able at that time to sell 3½ per cent. bonds at par. At the present time, the highest class of municipal and state securities sell on a 4½ per cent. basis, and railway corporations of greatest financial strength must pay 5½ to 6 per cent. or even more for money borrowed on either bond issues or short-term notes.

As for the second-class securities, issued by companies not so well known to the investing public, they must pay a proportionately higher rate.

So many misleading and false arguments are being based on these conditions in the financial world that it is proper to point out some of these fallacies. It is commonly urged, for example, that the present difficulty of the railways in selling bonds is due to the current of popular hostility—the anti-railway legislation, the growth of public-service commissions, etc., and the demands of the railway labor unions. We are far from denying that these elements have an influence with the investing public, but they are not the chief reasons why railways are unable to borrow money on favorable terms. The fact that the interest rate on all securities, industrial corporations, city bonds and government issues, has gone up at the same time as the rate on railway bonds, is proof positive that the cause is a general one and not a special situation due to conditions in the railway world.

There is, of course, the usual attempt to make political party capital out of the situation, and to charge the scarcity of money for investment to one or another political party. The fallacy of this idea is shown at once, however, by the fact that the condition is not confined to the United States but is world wide. It is a noteworthy fact that with all the limitation of competition that has gone on in transportation, industry and commerce, in the investment market the law of supply and demand operates absolutely without hindrance. Methods of international banking and exchange have made the whole world's reservoir of saved capital available to borrowers anywhere who are willing to meet the conditions and pay the price.

As one of the chief figures in the financial world recently said, "The condition we face is a demand for capital in excess of supply," and the reasons for this condition are patent almost upon their face. They are on the one hand, an extraordinary demand for capital, and on the other hand, a supply which is probably stationary or even diminishing. The abnormal demand for capital arises partially from the war in the Balkans and the revolutions in China and Mexico. Coincident with these, there has been extraordinary industrial activity in both Europe and the United States, making large demands for capital by all sorts of manufacturing and commercial companies. At the same time cities and states the world over are undertaking public works on an enormous scale. As typical of what is going on, we may mention the "Good Roads" movement and the movement for better municipal sanitation, as having alone added hundreds of millions of dollars to the public debt of American cities, states and counties during the past two or three years. Railways and other public-utility corporations all over the world are spending large sums for improvements made necessary by the growth of traffic and the demands of the public for better facilities.

On the opposite side, as we have said above, there is reason to believe that there has been, during the past two or three years, a diminished amount of capital available for investment. In the last analysis, as every economist well knows, the only source of money for investment in permanent improvements is the amount which is saved by individuals whose income is greater than their expenditure. While in the popular imagination, the huge incomes of the multi-millionaires loom large, their investments are, after all, trifling, compared with the savings of the thousands of people of wealth or moderate means, and these again are small compared with the savings of the millions of the total population. It is the accumulation of the small hoardings of millions of individuals by the savings banks and the life insurance companies, which are after all the chief reliance of those who wish to borrow money on bond issues.

It is common knowledge that the last four of five years have witnessed a great increase in the cost of living. This is partially due to an actual increase in the prices of the necessaries of life, but it is also largely due to a steady increase in standards of comfort and luxury. The development of the automobile is typical of the change which is going on. The wealthy man who was satisfied with an annual expenditure of a few hundred dollars upon his horses twenty years ago, now spends thousands upon automobiles. Coming down the social scale, the mechanic who is working for eight hours a day at a high scale of union wages, is very likely putting less money into the savings bank every year than he did twenty years ago when prices were lower and he was accustomed to do with less because his neighbors did.

Discussion of these changes might be carried much further, but it is evident that they have a vast effect upon the margin of income over expenditure, which alone constitutes the fund available for investment. It is important to note, moreover, that the changes we have been noting are not temporary, but to a large extent, at least, are permanent.

Of course, in the long run, where competition has free play as it does in the investment market, supply adjusts itself automatically to the demand. Higher rates paid for capital are an inducement to people to save money instead of spending it; and on the other hand the

higher rates which must be paid for capital, directly limit the number of enterprises which can be profitably undertaken.

A review of the situation would not be complete, moreover, without noting as one factor in the present financial condition, the extensive hoarding of money in both Europe and the United States. A general foreboding of possible impending trouble, whether it be due to a war in the Balkans or anti-railroad legislation in Kansas, has a world-wide influence in locking up savings that would otherwise be available for investment. It is not alone that the frightened French peasant hoards his gold in an old stocking instead of trusting it to the bank, but bankers the world over feel it only a measure of necessary caution to increase their cash reserves so as to be prepared for any eventuality.

The Problem of Economic Road Construction

ENGINEERING NEWS, as its readers can testify, has been foremost in the defense of highway engineers unjustly accused of incompetence in their work. We have shown again and again that competent engineering direction and freedom from political control are the first essentials to secure good roads. But we say nothing not perfectly well known when we say that the engineering profession has no reason to be particularly proud of its work on road construction during the past dozen years, even when carried on under the best conditions. It may be frankly confessed that the change from horse traffic to automobile traffic upset all past precedents of road-building practice and left engineers in the dark as to what procedure was best in road construction and repair.

But the coming of the automobile not only changed all the road-engineering problems; it also created an unprecedented demand for better roads. The automobile industry is wealthy and influential and the users of automobiles represent a large proportion of the men of means and influence in every community and state. The coming of the automobile multiplied tenfold the strength of the good-roads movement, and has led to far larger appropriations of public funds for road work than would have been deemed possible twenty years ago.

The engineers engaged in road construction, therefore, were compelled to launch out on new road work on a large scale just at the very time when they had to learn their business over again.

They did the best they could with such knowledge as they had; but they had to launch forth in many untried experiments, and we now know that many of these experiments have turned out badly.

It has seemed to us that it might be useful at this time to stand off and take a sort of bird's-eye view of "where we are at" in road construction. Is there anything the engineer can do to solve his problem better? If there is, most emphatically he had best make haste and do it; for unless we find a better solution for this problem than many that have been accepted in the past, the reputation of many engineers and of the engineering profession itelf is bound seriously to suffer. The voting and tax-paying public, which bears the burden of paying for good roads, has been deluded by the wild and absurd claims of good-roads boomers into the belief that good roads once built will cost less to maintain than the old dirt roads. Already they are finding their mistake and the shifty good-roads boomers are making a scapegoat of the engineer.

This is one of the reasons why it is time the engineer sat down and did some hard thinking on his own account to try and find out "where he is at" on this problem of road construction. It is in this attempt at a broad review that we may perhaps be able to offer something in the way of suggestion and aid.

In the first place, let us state the foundation principles that should govern in economic road construction. The first principle is that the road is most economical whose total cost per annum is the least; and the total cost per annum is equal to the interest on the cost of construction plus the annual expense for maintenance, plus an annual allowance for depreciation which will be sufficient to entirely renew the wearing surface of the road at the end of whatever term of years it becomes worn out so that its complete renewal is necessary.

This seems to an engineer, of course, a simple, self-evident statement; but it is not simple at all to the general public, which looks only at first cost and has no comprehension of the heavy outlay necessary on nearly all roads for maintenance and depreciation.

It is clear, too, that only an engineer (and an engineer who knows his business) can compute with any accuracy what the annual cost is of any type of roadway. For in order to determine the annual cost of a road, the average annual cost of its maintenance during its life must be known, and also the cost of renewing its wearing surface at the end of its life. We violate no confidence in saying that for many of the newer types of roadway, engineers have very limited information as to their life and their cost of maintenance. Besides this, the change from horse traffic to automobile traffic has made the engineer's former data as to life of the older types of road, such as ordinary macadam, wholly unreliable for use under present conditions.

The definition above of the most economic roadway as the one of least total annual cost does not take into account the extent of the roadway's use. It is, of course, true that the greater the amount of traffic upon a road, the larger the sum which may be properly expended upon it. In fact, for a complete determination of the problem of most economical roadway, the saving in cost of haulage by one type of roadway over another would have to be taken into consideration. This, however, is theoretical rather than practical, except where the saving in cost of haulage over a hard road compared with a dirt road is to be considered. Even here the current claims of the good-roads advocates as to the saving by hard roads over earth roads are wide of the mark. So far as the different types of paved roadway are concerned, it would be difficult to show any material difference in the cost of moving traffic over one type compared with another, provided they are in equally good condition.

We have said that it might be useful for the engineer to detach himself for a bit from the study of details of the road problem and to take a broad view of it. In such a broad view it may be set down that there are in general three kinds of road surfaces and only three. These are, first, the ordinary earth road, second, the road whose wearing surface is made of stone chopped up

into small pieces and stuck together and, third, the road which is paved with blocks laid close together to cover the surface.

Taking first the ordinary earth road, it is, of course, the cheapest by far in both first cost and maintenance cost. When in ideal condition, that is, neither so wet as to be muddy or so dry as to be dusty, it is the most agreeable roadway possible for light pleasure driving. Its worst fault is that in many soils it becomes a slough of mud and well night impassable during part of the year.

The engineer can do a great deal to improve the earth road and at no very great cost. Underdraining, proper crowning, and road dragging to smooth out the ruts and enable the surface to shed water can vastly improve the mud conditions; covering a clay surface with sand or a sand surface with clay has also worked wonders. It is a fact that engineers, as well as the good-roads boomers, have too much neglected the common earth road and the methods of its improvement so that it may be uncommonly good.

It is instructive to reflect that over 95% of the highways of the country are earth roads and, except for such improvement as surfacing with gravel or such other natural material as may be available at small cost, they are certain to remain earth roads for at least a generation to come. If, then, the engineer can make the earth road a better road, within reasonable limits of expense, he will do more for the cause of road improvement than can be done in any other way.

Nor is there anything impossible in this. At present, practically all the work on earth roads is being done by human muscle or horse power. When we have mechanical power successfully applied to road graders, road ditchers, road drags and like machines, we may be able to very much reduce the cost of improving earth roads, which means that we can afford to make a good deal better roads of them.

Turning now to the second class of roads, those made up of small pieces of stone stuck together, there are three broad varieties of this road; first, the road in which the pieces of stone are stuck together with mud—that is, the ordinary macadam road (commonly called "water-bound," which is an absurd term since water has no binding power); second, a road in which the stone fragments are stuck together with some bituminous material, a class which includes a wide range of pavements from a tar-sprayed macadam road to sheet asphalt, and, third, where the pieces of stone are stuck together with portland cement and a concrete roadway is produced.

The life of any roadway of this second type depends on the life of its binding material. It is because the binding mud which holds the stone particles of a macadam road surface together is too weak to bear the stress of automobile traffic that the road goes to pieces.

Under a traffic of iron-shod hoofs and iron-bound wheels, a water-bound macadam road is continually being rolled down and pounded down to a hard, smooth surface. But under rubber tires driven at high speed and power, the surface of the road is substituted to a heavy stress, the dried mud binder is ground away and carried into the air as dust and the stones are loosened from their matrix and spread over the road surface.

A gravel road is to be classed with a water-bound macadam, since it consists of small pieces of stone stuck together with mud; but it differs from it in that the pieces of stone are all very small, so that there are no large pieces to be loosened and roll on the top.

A gravel road made of material containing natural binding qualities stands automobile traffic better than a water-bound macadam. Heavy and fast automobile traffic will indeed ravel the road, but the gravel will mend itself under the impact of rubber tires whenever rain comes to wet it, as a water-bound macadam will not.

Wherever deposits of natural road-making gravels are available, therefore, they are deservedly given a high place in the estimation of road engineers. Before the automobile came, a gravel road was regarded as a cheap and inferior substitute for a water-bound macadam. Nowadays, some engineers question whether there is any place for the water-bound macadam; provided good gravel is attainable within reasonable distance.

Of course, building a gravel road for heavy traffic means something more than digging any old gravel out of a bank and dumping it in any old shape in the center of the roadway for passing wheels to spread and pack. Screening pebbles out of the gravel and mixing in sand and clay where necessary to furnish proper binding material for the gravel particles, are among the things which may be done to help make a gravel road permanent.

Many gravel roads heave and break up under frost action; but good drainage and careful maintenance to keep water from standing on the road surface will help to reduce this trouble.

Turning now to the roads in which small pieces of stone are stuck together, not with mud, but with resilient bituminous cement of asphalt or dried tar, these roads were a natural evolution from the water-bound macadam type when engineers sought for a binder that would stand the stress of automobile tires.

Every engineer knows that there is a time in the life of a bituminous macadam road when it furnishes an almost ideal surface, as springy and elastic and tough almost as rubber. If it only would stay so! Was there ever a type of road surface which produced such a large crop of successful admirers and also such bitter disappointments as the bituminous macadams?

We shall not here discuss the relative merits of the mixing and penetration systems or other of the many questions, concerning which volumes of literature have been written.

The central fact appears to be that the life of all roads of this type depends on the life of the various organic materials in the cement which holds them together. Experience has demonstrated that the life of some of these cements when exposed to the weather is very short. And when the "life" goes out of the cement and it becomes a weak, brittle, porous, friable mass, such as most engineers experienced in road construction know only too well, the road built with it goes to pieces.

Some bituminous cements have a far longer life than others. Eminent engineers and chemists have spent much gray matter trying to find how to tell a good bituminous cement from a poor one. All alike are black and sticky at the start and only chemical analysis will determine whether the material is good or bad. Indeed, it is objected by some that even the chemist is not able to infallibly tell the good from poor.

A great many million dollars have been spent during the past five years in buying tars and asphalts and oils, and incorporating them in road surfaces. If a fair ap-

praisal were made today of the remaining value in these road surfaces, we believe it would represent a very small percentage of the original investment.

Experience has certainly shown that if bituminous material is to be used to stick broken stones together for a road surface, the material and the work must be good enough to stand traffic for a reasonable term of years. Many good engineers have been forced into the use of cheap forms of bituminous macadam in order to cope with the dust nuisance and make worn-out water-bound macadam roads usable. But money spent in that way is like pouring water into a sieve.

The concrete road, built by sticking together pieces of stone with portland cement, has acquired a bad reputation from those who have laid concrete roads by various patented processes, and have not laid them well; and further because it has been laid where it has received a traffic that no form of broken stone road—whether stuck together with mud, bituminous cement or portland cement, could long endure.

During the past three years engineers have tackled the problem of making a concrete surface as good as can be made by the use of the best methods of mixing and placing concrete, and the concrete highway is now recognized as a strong competitor of bituminous macadam. Here again, success depends on making the roadway so well in the first place that the surface will endure traffic without injury for a long period of years. The success of the concrete pavement has been greatly aided by the change from horses to mechanical traction. A smooth, hard, concrete surface endures the shear of rubber tires without injury, but is ground up by sharp horseshoe calks and heavily loaded steel tires.

Turning now to the third type of pavements, those in which the road surface is covered with blocks, this type of roadway has been considered out of the question for highways, notwithstanding its wide use on city streets, on account of its high first cost. But, as we showed above, the first cost is only one element in the final cost of a roadway to the taxpayers. If, for example, a roadway costs for maintenance $400 per mile per annum, this maintenance charge alone will be as heavy a burden on the taxpayer as the interest charge at 4% on a road costing $10,000 per mile to construct.

This is merely an illustration of the fact that it will pay to spend several thousand dollars a year more on the construction of a road, if the annual expense for maintenance may be reduced to an amount that will be materially greater than the interest charge on the added cost.

So far as durability and low cost of maintenance under very heavy traffic are concerned, the block pavement is, of course, superior to any form of pavement composed of crushed stone stuck together. While the impact of horses' shoes slowly wears block pavements subject to heavy traffic, as in a city street, the wear of such pavements by automobile traffic is inappreciable. From another point of view, the advent of the automobile is favorable to block pavements. The macadam road gives a better foothold and is less severe on horses than the block pavement, and is also less noisy. But none of these objections hold where automobile traffic is concerned.

Again, the block pavement as formerly laid was jointed with some sort of bituminous material which gradually wore away under traffic, making a rough surface with many crevices to catch dirt.

But a block pavement, if it is to be smooth enough for high-speed traffic (and if it is not smooth, it will not be durable) must have a concrete foundation and a sand cushion between the blocks and the concrete. This brings the total cost per square yard for either wood block or standard stone-block paving too high for consideration on country roads.

We are thus reduced to artificial blocks of brick or asphalt, or possibly, to the small stone blocks recently brought forward in this country under the trade name of "Durax" paving. If these small stone blocks (about 3-in. cubes) could be produced on a large scale and sold cheap enough, the pavement might find an enormous field of usefulness. As far as durability is concerned, a 3-in. carpet of granite cubes on a street should last indefinitely. At present, however, the cost approaches that of a standard stone pavement.

Turning now to roads paved with brick or asphalt blocks, the use of the latter has so far been confined almost wholly to city streets. Brick pavements have been laid, however, on a large mileage of country roads in the Middle West, where the best paving brick is made and can be purchased at the lowest cost.

So far as the character of the finished pavement is concerned, a brick pavement laid according to the best specifications is nearly an ideal pavement, so far as smoothness, freedom from wear and low cost of maintenance are concerned.

The economic question for an engineer to settle is whether the extra cost of a brick pavement, over either concrete or bituminous macadam, is justified by its lower cost of maintenance and longer life.

The answer to this question will be different in different sections of the country, according to the relative cost of paving materials. In the paving-brick centers of Ohio and Indiana, a first-class brick pavement may be laid for little more than $2 per sq.yd. If the cost of first-class bituminous macadam is taken at $1.70 per sq.yd., and of concrete at $1.40 per sq.yd., most engineers would advise the more expensive pavement as the cheapest by far in the long run. But as one goes farther away from the paving-brick centers, where freight on the brick becomes a large item, and few contractors are expert in brick paving, the cost of brick paving rapidly rises, so that the condition of the problem changes.

To sum up our discussion briefly: The economic problem before the engineer is to build a good road which will have the least total annual cost. Assuming that the traffic is great enough to demand something more durable than a gravel or water-bound macadam road, he has a choice between concrete, bituminous macadam and brick. There is, and ought to be, sharp competition between these three interests. The problem of those interested in the concrete road and the bituminous-macadam road is to find ways and means to make these roads more durable and at the same time reduce the cost of their construction. There are large opportunities for this, we believe. By doing work on a sufficiently large scale, it may yet be possible to build good concrete roads for little more than a dollar a square yard and perhaps an equally low figure for good bituminous macadam may yet be reached.

Such reduction in cost, however, must not be at the sacrifice of durable construction. An average expenditure for maintenance of only 4c. per sq.yd. per annum will pay the interest on an additional expenditure of a dollar a square yard in the original construction.

An average expenditure of 4c. per sq.yd. per annum on maintenance is equivalent to $370 per mile per annum. There are few macadam roads carrying heavy traffic which are not now costing much more than this per annum to maintain and on many roads two and even three times this amount is now being spent for maintenance.

The interests which are advocating the construction of concrete roads have had the wisdom to see that the success of the concrete road depends first on securing such excellent construction that the surface will be practically permanent. The interests which are pushing the use of tars and asphalts in road construction must achieve at least as good a result or they will inevitably be left behind in the race.

LETTERS TO THE EDITOR

Water-Works Growth and Improvements, San Diego, Calif.

Sir—Your issue of Sept. 4, 1913, in which you give an account of the organization of the Department of Water, City of San Diego, you give the population of the city as 40,000. It is true that San Diego had about 40,000 population in 1910, but our growth has been so phenomenal that we have increased to practically double that amount at the present writing.

Without going into the claims that San Diego, according to Pope's Official Directory, has 90,000 population at the present time, allowing 2¼ for each resident's name, I would say that at the beginning of 1910 we had 8264 service taps while at the present writing we have 13,876. In the year preceeding January, 1910, we used 1,387,000,000 gal. of water. During the year 1912, we used 2,094,000,000 gal. It is hardly fair, when we have the increase in population that San Diego has experienced in the last two years, to still consider it a city of 40,000 population.

Last year San Diego bought a water system for $4,000,000, paying $2,500,000, and obligating itself to the extent of $1,500,000 to be paid in ten years. This coming October we have up for the vote of the people the issuing of bonds for the following improvements which shows you to the extent we are doing business in San Diego.

(1)	Diverting dam and conduit in Cottonwood Creek to prevent seepage losses	$185,000
(2)	Repairs to Dulzura Aqueduct, important for its proper use	30,000
(3)	Pipe line from Bonita to proposed 15,000,000-gal. reservoir to increase the capacity of the mains to the city and to eliminate a large portion of the present pumping	220,000
(4)	15,000,000-gal. reservoir at end of new main to secure a supply near city in case of temporary breakdowns and for substantial fire protection	75,000
(5)	Filter plant	60,000
(6)	Engineering for the investigation of additional water-supplies, including stream measurments, exploration of dam sites and surveys	50,000
(7)	Pipe line from proposed 15,000,000-gal. reservoir to prevent city distributing system	55,000
(8)	Rights-of-way	25,000
(9)	Pumping plants in the Valley of San Diego River for additional water-supply for emergency in dry years	200,000
(10)	Improvement of present distributing system	75,000
(11)	Caring for Otay seepage	5,000
	Total	$980,000

At the present time we have all the available force in the Department of Water working on the physical values and engineering features of the distributing and impounding system of the City of San Diego.

H. A. WHITNEY,
Hydraulic Engineer, Water Department.
San Diego, Calif., Sept. 12, 1913.

New York City at the Opening of the Nineteenth Century

Sir—I noted with interest the quotation from Mr. R. C. Hardman in your issue of Sept. 4, in reference to conditions in Pittsburgh, Penn., in 1807. I have a *Gazetteer of the United States*, published in 1805, whose title page states, among other things, that the volume contains "A Succinct Account of Indiana, and Upper and Lower Louisiana Territories—To Which Will Be Added a Description of More Than One Thousand Places, Not Noticed in any other Geographical Work. Embellished with a Handsome Map of the United States."

Its notice of Pittsburgh is not quite as flattering as the one referred to above, but it does state that "It consists of several streets, crossing each other at right angles; the number of dwellings by a late enumeration is 260, containing 1555 free persons, and 10 slaves, besides a jail and courthouse," etc.

The following extracts from the description of New York City may be of interest:

> The city is the largest in the state of that name, and second in the United States in respect to population, but first in commerce. It is situated on the S. end of Manhattan or New York Island, at the head of a bay, and in a county of its own name. . . . The N. end of the island is connected to the main land by a bridge erected over Spyten Duyvel Creek, called Kings Bridge. It is celebrated for a battle fought here in the late Revolution, between the American and the British forces, in which the latter gained the passage of the bridge. . . . The plan of the city is irregular, as the form and situation of the ground would not admit of a plan similar to that of Philadelphia* and some other towns of the United States. . . . Broadway is the most agreeable and pleasant part of the city; it extends due N. from that point which is formed by the junction of the Hudson and East River, occupying the height of land between them, and rising gradually as it advances northward. It is 70 feet wide and is ornamented with some handsome buildings. On the S. end is an elegant brick edifice, for the accommodation of the governor, besides 2 handsome Episcopal churches, and several neat dwellings, in different parts of the street. It terminates at the N. end in a triangular area, fronting the bridewell and almshouse, commanding an agreeable view of the bay and narrows.

*Not necessary to state that the "Gazetteer" was published in Philadelphia.

Wall-street stands elevated. It is generally 50 feet wide, and regularly built, with elegant dwellings. Broad-street extends from the exchange to the city hall; it was originally built on each side of a small creek which passed under the city hall. . . . The handsomest building in the city is federal hall. It is justly admired for the beauty, variety, and elegance of its architecture. . . . The scarcity of good water was formerly a great inconvenience to the citizens, but they are now supplied by means of pipes, which convey water through every street.

The citizens of New York have long been distinguished for their gaiety, politeness and affability. . . .

The present charter of the city is dated January 15, 1730; but there was another charter granted by governor Dongan, on the 22nd of April, 1686, which recites that the city of New York was then "an ancient city" and that the citizens "have anciently been a body politic and corporate."

From the above we may conclude that New York has been "some city" for some time.

M. H. Doughty.

5030 Stuart St., Denver, Colo., Sept. 10, 1913.

Waterproofing or Drainage of Tunnel Arching?

Sir—The article in your issue of June 26, describing the repair work to the lining of a tunnel in Germany, is very interesting to the writer on account of the utilization of dry rock packing over the arch, thus giving an opportunity for the free passage of the water from the overlying material to the drains in the side walls.

It does not appear from the description that the rock packing was placed primarily to facilitate drainage, but presumably it was used only as a means of filling the space opened up for the purpose of making the repairs, dependence being placed on a layer of waterproofing material to keep the water from reaching and passing through the arch.

In the original design for the Bergen Hill Tunnels of the Pennsylvania Railroad, provision was made for covering the whole of the arch with a substantial layer of felt and tar waterproofing, and drain pipes were provided for in the side walls for leading this to the drains in the bottom of the tunnel, the matter of keeping the tunnels dry being considered particularly important as they were to be electrically operated.

Considerable water was encountered during the excavation; so much so that in some sections the laborers had to be provided with oilskins, the flow amounting to as much as 100,000 gal. daily. In placing the lining, however, after a few hundred feet had been built, it was decided to do away with the waterproofing, except in a few very special cases, and rely on the dry rock packing over the arch to carry the water to the side drains. The wisdom of this has been amply justified by the results, the tunnels today being reported as "dry as a bone" and there have been no signs of deterioration in the concrete, due to the chemical action of the surface waters, which have been found in some of the other tunnels built through the trap dike forming the Hudson River Palisades. It may be of interest to note that two-thirds of the length of these Bergen Hill Tunnels is below the water level of the Hudson River and only 10% of the whole length is waterproofed.

It was the opinion of the writer that, even with a concrete arch, if absolutely free drainage were provided, there would be no difficulty in regard to the water leaking through. Experience on the first New York subway had shown that waterproofing was not always to be relied on in the presence of certain chemical constituents of the ground water and, where it is possible, as is generally the case over a tunnel arch, it may pay to take the section out a little larger and backfill carefully with rock to provide a free drain, rather than attempt to hold the water back and allow even the smallest head to accumulate. In view of the increasing use of electricity for the operation of tunnels and of railway lines in mountain country, this matter seems to the writer to be of considerable interest, as a dry tunnel is not only advantageous for the electrical installations but also in permitting better adhesion to the rail and, consequently, better tractive power for the locomotives.

F. Lavis.

50 Church St., New York City.
Sept. 19, 1913.

[The case of the German tunnel cited points to the importance of efficient provision for longitudinal drainage, or means by which the drainage water back of the tunnel lining is carried off freely and is prevented from accumulating.—Ed.]

The Design of Masonry Dams

Sir—The article in Engineering News of Sept. 4, 1913, by G. H. Moore, on "Neglected Principles of Design of Masonry Dams" should be read and pondered by every member of the profession. It is a clear and convincing exposition of the points raised by the author; but such perusal may leave in the minds of some readers an erroneous impression or implication, to wit: that teachers of engineering and practicing engineers have commonly overlooked these points. Undoubtedly, the textbooks have been to some extent defective and misleading, but it is the business of experienced teachers to correct such defects.

The author demonstrates clearly the necessity for conforming to the two-three triangle for a gravity dam. He then demonstrates that, under the assumption of full uniform uplift, the base of the dam should be about 1.58 times the height. Now $2/3 \times 3/2$ is unity, and if the reader will measure the cross-sections of some of the principal gravity types which the author has presented, he will find that nearly all of these designs conform approximately to these two fundamental principles; that is, base = height, nearly enough for "partial uplift."

But the writer would urge, as he has been accustomed to treat the case, that constructive details must not be divorced from theoretical considerations. It must be an essential requirement that the dam must be made watertight on the upstream face, a condition practically attained nowadays with concrete; and that we do not design dams with the idea that water will get into them or under them so as to cause uplift, *both* "full" and "uniform."

As to overtopped dams: the older readers of your journal will recall an interesting discussion of this subject in Engineering News, Vol. 51 (1900) by Trautwine, Rafter and others in a series of some seven or eight letters; also Mr. Rafter's discussion of a paper by Prof. Williams in *Trans. Am. Soc. C. E.*, Vol. XLIV, pp. 261, 316 and especially 334. This discussion had reference directly to the question of partial vacuum formed by the rush of the overflowing stream over the inclined face in such wise that the hydrostatic effect might be

seriously increased. This consideration your correspondent passes over in his excellent discussion wherein he shows that a safe section for a 30-ft. head becomes a menace or a failure if topped by a 10-ft. flood. Various different observers have testified to direct observation of partial vacuum behind a sheet of falling water sustained at an elevation of 1 to 2 ft. higher than that of the down-stream level. On this point Mr. Rafter had this to say:

One of the most important facts brought out in the past year's investigations in the Cornell Hydraulic Laboratory has been the formation of a vacuum more or less perfect behind the falling sheet when air is not freely admitted. With a weir 6 ft. high, the United States Deep Waterways Section, a head of 1.5 ft. has been observed to raise water behind the sheet to a height of 2 ft. above the level of the lower pool. The bottom boards of the plank aprons have been torn off frequently, apparently by the suction of the falling sheet at the toe of the dam. . . . The pulling off of the granite facing on the downstream side of the Austin Dam, while that at the crest remained practically intact, and other instances of similar phenomena that have been reported, seem to indicate that there may have been a very decided suction there on the occasion of its failure. This teaches that in the design of spillways, the practice of conforming them to the curve of the sheet, in order to obtain a smooth and compact overfall, should be reversed, and every precaution taken to prevent the sheet reaching the foot of the dam in a compact mass.

Some time ago the writer prepared the following notes for his classes in hydraulics, to impress upon their minds the fundamental importance of monolithic construction of masonry dams and sea-walls.

Long experience and observation have proved that large masses of masonry submerged or partly submerged by great masses of water are liable to be disrupted by the transmission of hydrostatic pressure throughout the mass whenever the water can enter through crevices, imperfect joints, etc., and gain access to void spaces within. Thus the pressure from a wave against the face of a sea-wall may be felt within and also throughout the extent of a porous foundation. Much more is this true of the pressure of the water against the upstream face of a dam and its foundation when imperfectly constructed.

Furthermore, the question of a partial vacuum caused by the flow over a dam or by the receding of a great wave from the face of a breakwater, has been discussed. It is believed by many engineers that in the case of dams the back pressure is increased quite appreciably by the suction produced in front. In fact, such vacuum has been seen, so to speak, behind an unbroken sheet of overflowing water by the maintenance of a column of water about 2 ft. in height above the level down-stream.

In the case of sea-walls the much greater magnitude of this back-pressure is proved by the fact that large stones well bonded with others have been gradually forced outward as though pushed by pressure within. (See Thomas Stevenson's "Harbors," pp. 116-124.) Also the material of the foundations of such walls is very commonly sucked out, as the term is, and many such structures have been destroyed by this undermining action. On the Buffalo breakwater, subjected to the storms of Lake Erie, the body of the work being solidly capped with concrete, manholes, more than 3 ft. in diameter, were left at intervals, reaching into the porous material within, and these were plugged with heavy blocks of concrete. Due to the pressure of storm waves, transmitted through the porous foundation, and the porous interior, these heavy plugs have been actually lifted from their seats; at first, probably, by the direct effort of the air compressed beneath them. Partial disintegration and settlement resulted at some points.

Having these facts in view, and remembering that stone, like granite, submerged in water, has an effective weight of only 100 lb. per cu.ft., we may next inquire how much back pressure, due to partial vacuum, would be sufficient to balance even this weight. Now 1 lb. per sq.in. of unbalanced atmospheric pressure which would be caused by a drop of only 2 in. of the barometric column, would mean 144 lb. on 1 sq.ft., so that a partial vacuum measured by a drop of considerably less than 2 in. of the barometer, if concentrated upon one face of a cubic foot of stone, would entirely counteract the weight and permit the waters to move it with perfect freedom while these conditions existed.

These conditions suggest that in all such construc[illegible], the barrier or resisting mass, must by all means be [illegible] solid, if it is to act perfectly, that is, it must be free [illegible] voids or imperfect joints. By the processes of nature, n[illegible] barriers or dams are made in terminal moraines, by th[illegible] tion of ice and water in first depositing rocks and [illegible] gravel in a confused mass, and then gradually compl[illegible] filling all the interstices with fine silt and mud by the [illegible] bined action of flowing water and pressure. Thus we [illegible] dams by the process of hydraulic fill.

From all that precedes, it would seem to be a fair co[illegible] sion that our chief anxiety should be to thoroughly fi[illegible] the voids, and that the method of putting a solid cap ov[illegible] porous substructure is wrong in principle.

Mr. Kinnipple, the English engineer, had striking suc[illegible] in saving old and much injured breakwaters by the pro[illegible] he termed "stock-ramming"; that is, by drilling holes at [illegible] tervals down through the mass to the base, and forcing in under pressure clay and cement grout, so as to fill all the voids. Certainly at Buffalo and in other cases where a cap, even very solid and heavy, has covered loose materials at the base, the works have given evidence of severe internal stress and have not withstood partial disrupture.

ROBERT FLETCHER,
Director, Thayer School of Civil Engineering.
Hanover, N. H., Sept. 13, 1913.

Sir—In your issue of Sept. 4, 1913, G. H. Moore deduces rules for the base width of gravity dams under different conditions of uplift. These rules tell a rather interesting story, thus:

If a base width of 1 is required when disregarding uplift, a base width of 1.291 is required with (1) uplift due to full head at the heel, varying uniformly to zero at the toe, and a base width of 1.583 would be required with (2) uplift, due to full head acting undiminished from heel to toe.

Wherever vertical drain tiles are introduced back of the upstream face, condition (1) appears to be the proper one to assume according to the few tests published on the subject (see Section G-H, Fig. 4, ENG. NEWS, July 31, 1913, p. 203). Where no vertical drains are provided, it would seem proper to assume the uplift pressure on the foundation distributed according to a condition lying midway between (1) and (2). Instead of adding to the base width, the writer would place the additional material in the form of buttresses on the downstream face, spaced at certain intervals, depending upon the height of the dam. In cases of doubt as to the quality of the foundation rock, the excavation for the buttresses should be made deeper than the main dam. Such a dam would act both as a cantilever and as a beam, it could not overturn or slide before the buttresses had crushed or sheared off.

The writer has in his file the records of 98 dam failures, collected largely from information published in engineering journals, and a study of these records shows that nearly all gravity-dam failures have been due to sliding or overturning. Buttresses would most effectually lessen both tendencies.

However, before the writer would use a gravity dam, he would thoroughly investigate the possibility of using some other type. Any other type would almost always be stronger, as on the very face of it it is evident that a gravity dam cannot be built economically because it is not possible to place the material so that all of it can be loaded when the reservoir is full of water. Half of the material is inactive under this condition. Mr. Moore suggests that the solution is to be found in the use of the arch type of dam, and the writer thoroughly agrees with him. Wherever the dam site is fit for the use of an arch, nothing else is safer and more economical to use. Without a doubt, practice has demonstrated this fact, as no arch dam has ever failed. (The Puentes dam in Spain,

which was polygonal in plan and 164 ft. high and had a masonry section larger than a gravity section failed by undermining. It was built on piles in a gravel bed.) So far the main objection of the engineering profession to the use of the arch dam has been that this structure could not deflect sufficiently at the foundation to carry the load acting as an arch, and that the load here, therefore, would have to be carried mainly by shear and cantilever action. The common theory of arch dams is also at fault as it does not consider the influence of Poisson's ratio. The lateral expansion of the lower layers of the arch, due to the weight of material above, forces the arch to take up more load near the foundation than is commonly supposed. (See ENG. NEWS, Aug. 1, 1912, p. 208.)

In any more or less V-shaped cañon an arch can be built in such a manner that it will require very little deflection at the foundation to carry the total load. This can be accomplished by designing the arch so that it subtends a constant or nearly constant angle of about 120° at all elevations. Theoretically, the most economical angle to use is 133°, but practically, it is about 120° at the crest, and somewhat less toward the bottom, depending upon the shape of the cañon. This condition compels the diminishing of the length of the radius of the upstream face from the crest toward the foundation where it often is several times shorter than at the crest. As the maximum deflection of the arch when loaded is proportional to the square of the length of the upstream radius, it is easily seen that the deflection at the foundation of an arch dam which subtends a constant angle may be so small that it is within the elasticity of the material. (See ENG. NEWS, Aug. 1, 1912, p. 209, for full explanation. Several dams of this type are at present being constructed.)

It is not possible to eliminate the deflection of the arch entirely, but, even if it were, it would not be economical to do so. The dam has a certain section and for the sake of economy the cantilever should also be loaded some, thereby not only relieving the arch in the middle, at least, but steadying it as well. The two sets of compressive forces act 90° apart on the same body, thereby tending to support each other laterally and increasing the factor of safety.

In a fairly narrow V-shaped cañon, such as these generally are west of the Rocky Mountains, it is not possible to build a high gravity dam at all. The section, of course, can be dimensioned as a gravity cantilever, but it will not act like one, at least not in the lower portion. Here the load is carried mainly on the horizontal beam. This should be very clear when it is considered that a beam uniformly loaded and held at both ends will support four times as much as a cantilever carrying the same load (maximum at the bottom and nothing at the top). Whenever the beam is four times longer than the cantilever, it will support half the load. For a dam 250 ft. high the bottom width of the cañon would have to be well toward half a mile before the beam action would be negligible in comparison with the gravity action. Generally, the beam action is very dominant toward the bottom, introducing tension along the upstream faces between the abutments and the points of contra flexure and along the downstream face between the two points of contra flexure. There is only one way of eliminating this tension and that is by arching the dam. This beam action toward the foundation relieves greatly the foundation pressure, as long as the beam has not failed in tension, and as long as the expansion joints, if any, are placed at or near the points of contra flexure only. These points are located a distance of $0.2113 \times$ span from either abutment. The beam section also tends to strengthen the structure by taking a large part of the load from the cantilever, but to avoid tension the beam must be curved even in quite long dams. Such a design cannot be called an arch dam. The factor of safety has been improved, but much of the material is still inactive or only partially active. The design is neither scientific nor economical.

An arch which subtends a constant angle from crest to foundation, of 120°, or a little less, has the material placed where it does the most good, and will, therefore, give the cheapest structure for any desired factor of safety. This condition is especially marked in high dams built in narrow cañons. In true arch dams, uplift pressure does not need to be considered at all, as it can never be large enough to float the dam. Overflow can safely be allowed, and ice pressure is very easy to take care of by providing extra thickness at the ice level only. There is no long-moment arm to consider. Such an arch can be economically designed with a factor of safety between 5 and 10. Exceedingly few enterprises could stand the expense of a straight gravity dam with such a factor of safety, and, therefore, the factor of safety of this kind of structure is cut down to conform to what the enterprise can stand. Even with such a low factor of safety as 2 or 3 a gravity dam will at times appear over twice as heavy as a true arch-dam section, and this is the main reason why engineers for so long have been able to convince financiers and others that public confidence in an enterprise demanded a gravity dam in preference to any other type. As the general public is supposed to know less about dams than civil engineers, they can easily be led to believe that a heavy gravity wall is safer than a more slender arch, and if the enterprise will stand the extra cost, the gravity section is built. This extra money could have bought higher-grade machinery for the power plant, or might have been saved. It is one of the engineer's duties to conserve his clients' resources as much as possible.

LARS JORGENSEN.

Chronicle Bldg., San Francisco, Calif.,
Sept. 12, 1913.

Sir—In an article on "Neglected First Principles in Masonry Dam Design," published in your issue of Sept. 4, 1913, George H. Moore makes some statements that are incorrect and some that are debatable.

(1) Triangular Profile. All gravity profiles for masonry dams are not merely variations of a simple triangle, whose base equals two-thirds of its height. In many famous dams, built according to the profiles proposed by De Sazilly, Delocre, Rankine, etc., the controlling principle of the design is to keep the maximum pressures in the masonry at fixed limits of safety, whereas, in the triangular profile, these pressures are allowed to increase gradually from nothing at the top to a maximum at the base. The width of the base of the triangular type is about two-thirds of its height if we have only to consider the pressure of the water on the upstream face, but

if we have to consider ice pressure and uplift, this width must be considerably increased.

(2) Referring to p. 40 of the Sixth Edition of Wegmann's "Dams," Mr. Moore states that "it seems rather farcical to assume limiting 'maximum pressures' such as 14.35 or 15.16 tons per sq.ft." If he will read that page again, he will see that these pressures were not given as "limits," but as the maximum pressures reached—respectively, at the front and back face—at the base of a dam, 200 ft. high, built according to the triangular type, in which the pressures in the masonry increase gradually from the top to the bottom.

(3) Ice Thrust. Mr. Moore makes some criticisms about the fact that the eminent experts, who reported about the Quaker Bridge Dam, assumed 43,000 lb. per lin.ft. as the ice pressure. He thinks that they should have taken 45,000 or 50,000 lb. per ft. For the Wachusett and Olive Bridge dams, 47,000 lb. per lin.ft. was assumed for ice pressure and for the Cross River Dam this pressure was taken as 24,000 lb. per lin.ft. There is no logical reason why we must take a multiple of 5000 in making allowance for a force, whose exact value we do not know.

(4) Uplift. Mr. Moore does not approve of the assumption (made in designing the Wachusett, Olive Bridge, Cross River, Croton Falls, etc., Dams) of an upward pressure under the base, varying from two-thirds of the full head at the upstream side to zero at the downstream side. He appears to think that the full head should be assumed to act with undiminished force from heel to toe. There is generally a considerable quantity of refilling above the base of a dam. Water leaking out of the reservoir has first to percolate through this refilling, and then through seams in the rock that are generally filled with earth, gravel, etc. If there are any open seams under the base of a dam through which water flows with undiminished head, they will affect, in most cases, only a small percentage of the whole base of a dam. It seems, therefore, justifiable in ordinary cases to assume the possible uplift at the heel to be less than the full head in the reservoir, and to diminish uniformly to zero at the toe.

If we take the full head of the reservoir to act under the base and an ice pressure of 43,000 lb. per lin.ft., we arrive at the profile proposed by J. D. Van Buren (*Trans. Am. Soc. C. E.*, 1895), which, for a height of 250 ft., has a base of 352 ft. With those assumptions, the base of the New Croton Dam would have been over 400 ft., instead of 206 ft., as actually built.

(5) Mr. Moore objects to the statement made by L. A. B. Wade, M. Inst. C. E., and concurred in by the writer, that curved dams are only to be recommended for comparatively narrow valleys. If a curved dam were built across a wide valley, the pressures resulting from arch action would be greatly in excess of those caused by the dam's resisting the water by its weight only, and the volume of masonry would be considerably increased by the additional length of the plan.

(6) Mr. Moore thinks that textbooks on dams do not warn the novice sufficiently about the additional stresses caused by a flood passing over the crest of a dam. In Wegmann's "Dams," to which he refers several times, he will find a whole chapter devoted to that subject, in which it is stated that many failures have occurred because the differences between overflow wiers and dams designed to have their crests always above the water line were not taken into account.

(7) Dam Failures. Most of the masonry dams that have failed have been comparatively low overflow wiers, built across rivers which are subject to great floods. The writer recalls only the following five cases of masonry dams, 50 or more ft. in height, that have failed:

Year	Name	Location	Height ft.	Cause of failure
1802	Puentes	Spain	164	Pile foundation
1881	Habra	Algiers	110	High flood—poor masonry
1895	Bousey	France	72	Previous sandstone foundation
1900	Austin	Texas	68	High flood—poor foundation
1911	Austin	Penn.	50	In litigation

In four of these cases the failure was due to poor foundation and in one case it was caused by bad work.

E. WEGMANN,
Consulting Engineer, Department Water Supply, Gas & Electricity.
13 Park Row, New York City, Sept. 17, 1913.

NOTES AND QUERIES

In the article on the Medina Valley Irrigation Project, published in our issue of Sept. 11, 1913, a typographical error occurred in the paragraph headed "Flumes," p. 511. The 9½-ft. semicircular Hess flumes were made from galvanized toncan metal, not "toneau" metal. The material was the product of the Stark Rolling Mill, of Canton, Ohio.

ERRATA—The illustration in connection with the article on methods of finding the intersection of wing walls with the main abutments of bridges in our issue of Aug. 21, 1913, p. 366, had two errors, which have been called to our attention by Frederick C. Stauffer, of Hagerstown, Md. In Fig. 1 the distance marked "h" should have extended to the top of the batter only, as is apparent from the formula, and in the same illustration the angle marked ($\phi - \theta$) should be, of course ($\theta - \phi$).

In a letter published in our issue of May 8, it was stated that the artillery which did effective work in some of the battles which took place in the City of Mexico last spring, was under direction of a Mexican military officer who received his military education in France. A prominent Mexican engineer writes us from Mexico City stating that all officers in the Mexican Army are trained in the Mexican Military College at Chapultepec, and that if any officer of the army has studied in France it must have been as a post-graduate student.

P. H. M., of Guild, Tenn., writes: "To those who travel over railways on foot, the pace fixed by the spacing of crossties is nerve wrecking in the extreme. Let the railways space their ties 30 in. c. to c. and bring joy to pedestrians."

We give space to the suggestion because it is a remarkable instance of suggesting exactly the wrong thing. What the railways ought to do and would be glad to do is to make walking on their tracks as disagreeable and difficult as possible. As has been many times pointed out in these columns, more people are killed while walking on railway tracks than are killed in all the train accidents four times over. Instead of spacing ties farther apart, the increase in rolling-stock weights and train speeds and the trouble with broken rails all indicate that ties should be spaced as close together as they can be tamped.

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Grade Crossings of Highways on the lines of the Pennsylvania R.R. system still number 13,027. In the eleven years since 1902, there have been eliminated on the different lines of the system, 1052 grade crossings, at a total cost of $66,641,294, or an average of over $63,000 per crossing removed. A large portion of the crossings removed has been in towns and cities where the cost, including land damages, etc., is much greater than in the country. It is estimated, however, that the average cost of eliminating the remaining grade crossings on the system would be at least $50,000, or a total investment of over $600,000,000 to eliminate all the grade crossings on the system. As the expenditures during the past decade on grade-crossing removal have been at the rate of about $6,000,000 a year, it would require a century with this present rate continued to eliminate the remaining crossings.

Concrete Road Construction*

By A. N. Johnson†

Owing to the nature of a concrete pavement there are involved in its construction certain principles quite different from those entering into the design of most other pavements. The fact that a concrete pavement consists of large slabs of rigid material, having a coefficient of expansion due to temperature changes very nearly that of steel, demands provisions for such changes.

As a concrete pavement possesses far less resiliency than most other street pavements, the stresses from traffic loads are greatly increased. This is particularly true of the blows delivered to the surface of the pavement by heavy horse-drawn traffic. Moreover, as all the surface is liable to receive such stresses, it is necessary that every portion of it shall be equally well constructed. It is, therefore, of first importance in the construction of a concrete road to have the greatest possible uniformity in the composition of the concrete. It is not only necessary that each batch of concrete shall have the requisite amount of cement and properly proportioned aggregate, but that every portion of each batch shall be so deposited in the road as to be as nearly uniform as possible.

Again, owing to the brittle character of the concrete, it is evident that depressions in the foundation causing a settlement of the pavement will be manifested by cracks, while such depressions occurring in a pavement of more resilient character, as for instance in most all forms of macadam construction, may not cause any serious break in the surface. Therefore the utmost care should be taken to provide proper drainage for the foundation soil, perhaps even more care than in many other forms of construction.

EXPANSION OR CONTRACTION JOINTS

A concrete pavement is to be regarded as constantly moving. As the temperature increases, the pavement lengthens and with a fall in temperature it shortens. It is evident that provision for these variations must be made in the design of the pavement. Likewise it has also been shown by recent investigation that the absorption of moisture induces an increase in the bulk of the concrete, while the loss of moisture produces a shrinkage from which it will be readily appreciated that climatic changes introduce very complex conditions.

To prevent formation of cracks in a concrete road, in a haphazard way, joints must be arbitrarily placed in the pavement at the time of construction. As every joint in the pavement is a source of weakness, which the traffic will detect and which will afford an opportunity for moisture to penetrate the foundation, it is highly desirable to make as few joints as possible.

If the coefficient of friction of the concrete with the soil is assumed as unity, a slab of concrete 25 ft. long may be pulled over the foundation without exceeding 20 or 25 lb. tensile stress. Therefore if expansion joints were placed every 50 ft., the center of the slab, as the slab contracts, would develop a stress in the concrete within allowable limits.

If a crack, due to shrinkage that occurred in the pavement, remained compressive, that is if it did not subsequently become filled with grit that would prevent the crack from closing as the pavement tended to swell, either from a higher temperature or absorption of moisture, there would be no great necessity for providing beforehand for expansion joints. This is based on the fact that concrete as it sets is observed to shrink an amount about equal to its expansion due to a change in temperature of 76° Fahrenheit, and the small shrinkage cracks which occur offer sufficient room for subsequent expansion of the pavement due to any expected rise of temperature.

But the joints will not remain free of grit, with the result that compressive stresses of over 1000 lb. per sq.in. may be developed which are sufficient to buckle the comparatively thin slab of a concrete road. It is therefore important that expansion joints be provided and moreover that they be constantly maintained so as to be always compressible, which requires that they shall be filled with a plastic material, either a suitable coal tar or asphaltic pitch.

Various devices for the construction of expansion joints have been tried. In some cases ordinary wood paving blocks have been laid, on the theory that the shrinkage of the wood blocks in dry hot weather would provide sufficient room for the expansion of the concrete and that in cold weather, usually wet weather, as the concrete contracts the wood blocks will swell and the joint remain filled. Steel plates, cut to the shape of the crown of the road, have been manufactured, with which each edge of the joint is lined, the space between the plates being filled with pitch.

It should be observed that there is very likely to be some unevenness at the joints, due either to faulty construction or subsequent wear, so that it is desirable, if traffic is to be inconvenienced the least possible, to place the joints at other than 90° with the center line of the pavement. An angle of 60° with the center line of the road has been successfully used and found to add much to the comfort of traffic.

MATERIALS

Attention has been called to the fact that every portion of a concrete road should be of a high-grade concrete and also uniform. Many failures of concrete roads, due to raveling under traffic, may be explained by a lean mixture or a lack of uniformity. If a successful concrete pavement is to be laid, a concrete rich in cement must be used. It is evident that the strength of the pavement to resist the action of traffic depends upon the strength of the matrix or mortar in the concrete, assuming a proper aggregate has been employed. Also if each particle of the aggregate is to be held in place, it is necessary that there shall be a sufficient amount of matrix entirely to surround each piece. To accomplish this purpose, it is first necessary that the mortar be rich in cement and second that the concrete be rich in mortar. Probably quite as many failures have been due to a lack of mortar in the concrete as to a lack of cement in the mortar. If every particle of aggregate is to be surrounded by mortar, there must be mortar in excess of the voids in the coarser aggregate. Therefore, if failures have occurred with mixtures providing but 50% of mortar, as would be the case for example in a 1:2½:5 or 1:2:4 mixture, no great advantage would be gained by merely increasing the amount of cement and leaving a deficiency of mortar, for example, substituting for the above mixtures a 1:1½:3. A mixture that increases this proportion of mortar should generally be used; a 1:2:3½ mixture may be recommended.

Each batch of concrete must be thoroughly mixed and, as it is deposited in the road, great care should be exercised that the mortar does not flow to the edge of the pile and leave a core of aggregate with insufficient mortar. This is quite likely to happen and must be remedied by workmen who should be provided with rakes or shovels to distribute any such nests of aggregate. A little care and watchfulness will entirely obviate any difficulty from this source.

The nature of the aggregate will determine the wearing qualities of a concrete road. It is therefore important that only hard, sound materials be used for this purpose. In general, limestones and similar soft rocks are not to be recommended, while quartzitic or flint gravels afford widely dispersed sources of excellent materials.

DRAINAGE

It has been observed on some concrete roads that longitudinal cracks had occurred which are thought to have been due to the seepage of water under the outer edges of the concrete slab, thereby softening the foundation and causing a movement of the concrete slab by frost action. To prevent this it is recommended that a shallow trench about the width of a shovel be constructed under each edge of the pavement, this trench forming a blind drain to be filled even with the subgrade with some coarse material and that lateral blind drains be placed from 40 to 50 ft. apart across the shoulders of the road, these cross drains extending from the longitudinal drains to the gutters or side ditches thereby preventing any seepage of surface water under the edge of the pavement in the foundation.

TWO-COURSE CONSTRUCTION

Many concrete pavements have been constructed in two courses, using a leaner mixture for the lower course and a richer mixture for the wearing surface. Evidently, this is an economical arrangement and would be recommended were it not for the unsatisfactory results obtained due to the fact that at the junction of the two classes of concrete there is developed a horizontal plane of weakness which would be caused by even a comparatively short delay in applying the top course. Under exposure to the hot sun, whereby the surface of the pavement becomes of a higher temperature than the lower portion, there in a tendency for the pavement to become slightly convex on the upper or wearing surface. If there is a horizontal plane of weakness near the convex surface, the upper layer of the pavement may become separated from the lower layer. And this has actually occurred. Soon after this takes place, the surface cracks under traffic and rapidly deteriorates. Therefore unless some method can be found by which the top layer of rich mixture

*Paper presented before the Permanent International Association of Road Congresses, London, 1913.

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can be deposited simultaneously with the leaner mixture of the lower course, it is recommended that the whole pavement be made of uniform quality throughout equal to that desired for the wearing surface.

CURING THE CONCRETE

A most important part of the construction of concrete roads, and one that has been very often neglected, is a proper protection for the concrete while setting so that there will be no lack of moisture at this time. As soon as the concrete is a few hours old it should be covered with canvas which is kept moist. This canvas is to be replaced by a layer of earth which should be kept well wet for a period of ten days to two weeks.

CROWN

A concrete road requires perhaps less crown than any other form of paving surface, scarcely more than the eye would demand for appearance sake. One eighth to one quarter inch per foot will be found sufficient.

For convenience in construction, the roadbed may be made practically level and it is evident should be constructed with considerable care so that it does not become necessary to fill depressions in the roadbed with expensive concrete. The crown may be given by making the roadway slightly thicker at the middle than at the sides.

THICKNESS

A thickness of 6 to 8 in. for the concrete seems sufficient for all ordinary conditions. On roads 20 to 24 ft. in width, an average of 7 in. may be used with 8 in. at the center and 6 in. at the sides.

A form of construction that may prove desirable, where the greatest economy must be exercised, would be to provide a comparatively narrow strip of concrete at the center with a good macadam construction for the shoulders. This would answer for those roads where the traffic at a given time of day is nearly all in one direction. Under these conditions a strip of concrete 10 to 12 ft. wide at the center would take practically all the wear while the narrow strip of macadam at either side, 3 or 4 ft. in width, would suffice for the occasional passing of vehicles.

This character of construction is particularly applicable to a vast mileage of highways in America where such an enormous percentage is merely earth roads and where at present the maximum length of roads at the lowest cost possible is of the utmost importance.

FINISH

A concrete road should be left slightly rough as would be effected by a wood float. The templet which is used to give the shape to the surface of the road can be so devised and handled as practically to give the desired finish to the surface with the possible exception of here and there a slight imperfection which should be remedied by men with hand floats working from a lightly constructed bridge thrown across the road. It is highly desirable, however, that as little as possible be left to the hand finishers as there is inevitably a tendency on their part to work slight depressions in the surface of the concrete which can scarcely be detected until the concrete has set and it is too late to afford a remedy.

CONDUCT OF CONSTRUCTION

The actual work of construction consists mainly of two parts: First, the preparation of the roadbed and hauling of materials thereon in such quantities as may be needed ready for the mixer. Second, placing the concrete and trimming the road sides.

The mixer used should be of a type especially adapted for this work, one which will move under its own power along the road as the work progresses and provide convenient means for handling the material onto the road.

Attention is called to the fact that the success of the road primarily falls upon the second portion of the work, which, however, involves but 9% of the total cost. It is suggested therefore that the public department having in charge a considerable mileage of this construction could well carry it on under two divisions, allowing the first part of the work to be done by contract while the actual placing of the concrete should be done by day labor under the immediate supervision of the officials of the department, in this way securing with the least trouble and expense assurance of proper construction in every particular. The organization for placing the concrete is compact, easily controlled by one man, and moreover this portion of the work moves along rapidly and uniformly so that its cost from time to time should vary but little and can be estimated with precision.

COSTS

The difficulty of presenting cost data that would be of very general application is fully appreciated. The following table is offered together with such general information as to conditions as may prove of some interest if not of actual value.

ESTIMATE OF COST OF 1 SQ.YD. OF CONCRETE ROAD 7 INCHES THICK

No profits or overhead charges included.

Labor.....25c. per hr.
Team and driver.....45c. per hr.

	Length of haul ½ mi.	1 mi.	2 mi.	3 mi.
Superintendent, watchman and miscellaneous labor	0.055	0.055	0.055	0.055
Shaping roadbed and trimming shoulders	0.083	0.083	0.083	0.083
Loading and hauling materials	0.116	0.153	0.218	0.296
Mixing and placing	0.109	0.109	0.109	0.109
Cost of sand and gravel, at $1.50 per cu.yd., f.o.b. destination	0.379	0.379	0.379	0.379
Cost of cement at $1.20 bbl.	0.364	0.364	0.364	0.364
Expansion joints spaced 50 ft.	0.025	0.025	0.025	0.025
Coal, oil and miscellaneous supplies for mixer	0.007	0.007	0.007	0.007
Forms and other lumber	0.005	0.005	0.005	0.005
Total	1.143	1.180	1.245	1.323

For a thickness of 6 in. a similar analysis gives total costs per sq.yd. for the various hauls as follows: ½ mi., $1.003; 1 mi., $1.035; 2 mi., $1.091; 3 mi., $1.158.

CONCLUSIONS

In adopting concrete for a road surface, it should be borne in mind that if a hard rigid form of pavement is undesirable for the traffic to be accommodated, it will not prove satisfactory. For example, with a large amount of light, horse-drawn traffic some more resilient form of pavement would be found better adapted; but where a large amount of motor and heavy horse-drawn traffic is to be provided for, concrete pavements are proving satisfactory. There are experimental data at hand which seem to indicate a concrete pavement to be one of the must durable forms of construction that have been employed, and, under many conditions, the most economical.

The wide distribution of materials suitable for concrete makes this form of construction of the widest application and in fact in many areas where there is nothing but gravel deposits, poor for ordinary road purposes, a concrete road becomes the most economical and durable pavement possible. Moreover it does not require exceptional skill on the part of the workmen, but may be successfully laid, under careful supervision, with any reasonably good labor.

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The Proposed Shoal Lake or Greater Winnipeg Aqueduct

Brief mention was made in our issue of Sept. 18 (p. 574) of the proposed new water-supply for the Greater Winnipeg Water District. The attention of prospective bidders was particularly called, at the suggestion of T. R. Deacon, mayor of Winnipeg, to the desirability of examining the route of the aqueduct before the vigorous winter of Manitoba sets in. Since the note was written, we have received a copy of the report on this project made by Rudolph Hering, Frederic P. Stearns and James H. Fuertes, and are thus enabled to give some details of the proposed supply. Before doing so, attention may be called to the vigorous way in which the project is being furthered by the officials of Winnipeg and neighboring municipalities.

The board of consulting engineers, already mentioned, convened in Winnipeg on May 10, 1910, made investigations on the ground, studied existing and subsequent surveys made by the city, and signed its report in New York on Aug. 20. The report was read in Winnipeg on Aug. 29, adopted by the officials of the Water District on Sept. 6, and on Sept. 8 the city council of Winnipeg appropriated its share of the estimated cost, subject to ratification by popular vote on Oct. 1. It is confidently expected that the vote will be favorable, in which case detailed plans and specifications will be drawn as soon as

possible and bids invited, it is hoped, this winter, so construction can be started in the spring of 1914. The engineers estimate that four or possibly five seasons will be required to complete the work.

The proposed source of supply is Shoal Lake, which, it is estimated, will yield water enough for a population of 850,000. This lake is connected with the Lake of the Woods and they together "can furnish a practically inexhaustible supply."

In brief, the project includes a dike 5070 ft. long to divert the colored water of Falcon River from the lake; a channel 3300 ft. long to connect Snowshoe Bay with Indian Bay; 85 miles of concrete aqueduct (mostly plain, but partly reinforced) with a capacity of 85,000,000 Imp. gal. (102,000,000 U. S. gal.) from Indian Bay to the site of a reservoir not to be built at present; about eight miles of 5-ft. steel pipe to the Red River, 900 ft. of 5-ft. cast-iron pipe in a 9-ft. tunnel beneath the Red River, and a little over two miles of 4-ft. cast-iron pipe from McPhillips St. reservoirs in Winnipeg to Victoria Park, making a little over 10 miles of pipe, having a capacity of 25,000,000 Imp. or 30,000,000 U. S. gal. per day, which capacity can be increased first by pumping and second by a duplicate pipe; 85 miles of railway and (presumably) the same length of telephone.

The estimated cost of the dike, channel, 95.35 miles of concrete and metal conduit and various appurtenances, is $13,045,600, but this does not include water damages, land, branch pipes to the several municipalities, nor interest during construction. Nor does it include the proposed 250,000,000 Imp. gal. (300,000,000 U. S. gal.) reservoir at the end of the concrete aqueduct, about one mile east of Transcona, estimated to cost between $300,000 and $400,000; nor the proposed pumping station at this point, for which no estimate is included in the report.

The population of the Greater Winnipeg Water district in May, 1913, was estimated as 225,000, of which about 200,000 was in the city of Winnipeg. The report states that the "present population is twice that of seven years ago and five times that of fifteen years ago." The water consumption has increased from 32 to 47 Imp. gal. (38 to 56 U. S. gal.) per capita from 1902 to 1912 (evidently based on population actually supplied). The consulting engineers believe that 85 Imp. gal. (102 U. S. gal.) per inhabitant should be allowed for the future needs of the district "as the average for the year," and 100 Imp. gal. per inhabitant for some months in the year. The aqueduct capacity is based on the latter figure. It is assumed that the proposed concrete aqueduct will serve the district until 1944, or 25 years after its probable completion; but that the pipe line will serve only two or three years after completion, unless resort is had to pumping. It should also be noted that the upper end of the aqueduct, for some nine miles through a summit cut adjoining Shoal Lake, will, at full lake, carry 120,000,000 Imp. gal. per day, gravity flow, which could be maintained at low water, also, by a slight expenditure for low-lift pumping.

Shoal Lake has a drainage area of about 360 sq.mi. and (including?) a water surface of 107 sq.mi. It is at the same level as the Lake of the Woods, with which it connects at Ash Rapids. No yield figures for the drainage area are available, but deductions from other drainage areas indicate a yield of 70,000,000 to 93,000,000 Imp. gal. per day for the minimum year. The storage area of the lake is so great that the water in a single foot of depth would supply 850,000 people for 8.5 months at the rate of consumption assumed in the report. Moreover, the conection with the Lake of the Woods, the report states, reserves "a practically unlimited supply of water, and any supplementary supply taken from the Lake of the Woods would, after its extremely slow passage through Shoal Lake, become as thoroughly bleached and as satisfactory in quality as the water of Shoal Lake itself."

Some further details of the proposed works may now be given. The dike to divert Falcon River would be curved in plan, about a mile long, composed of sandy and gravelly material carried about 4 ft. above high water in the lake, and riprapped on the water side. The channel between the two bays would be 35 ft. wide and 7 ft. deep.

The details of the intake are not definitely settled, but a gate and screen chamber on the shore is proposed, and apparently the intake will not extend far into the bay nor be in deep water.

The bottom of the aqueduct at its intake end is at Elev. 324 ft. and at the lower end of the reinforced pressure section of the concrete portion, 84.72 miles distant, 83 ft., but there is a dip to Elev. 72.92 in the reinforced section at the lower end. The hydraulic grade line is based on the high-water level of the proposed reservoir at the lower end of the concrete aqueduct, which is at Elev. 68.54 ft. High water in the McPhillip St. reservoirs, in the city, is at Elev. 41.31. The discharge capacity of 85,000,000 Imp. gal. per day is based on a level of the bay 3.75 ft. below the high-water level and on the high-water level of the proposed reservoir, just mentioned.

The concrete aqueduct is designed to have a continuous down grade, with no portions under pressure except at certain valley crossings and where subjected (ultimately) to the back pressure of the reservoir at its lower end. Except where under pressure (about 7½ miles out of some 85), it will be of horseshoe shape. To save summit excavation, the slope is only 0.11 ft. in 1000 ft. for the first 6¼ miles. Here and nearly three miles beyond, where the slope is 0.24 ft. per 1000 ft., the cross section is 9 ft. high and 10 ft. wide. From there on, it varies with the slope, the smallest section being 5.1x5.1 ft., with a maximum fall of 2.83 ft. per 1000 ft. For 13,000 ft. beneath the Brokenhead River valley, where the aqueduct will be some 10 ft. below the hydraulic grade line, the cross-section changes to a 7.2-ft. circular reinforced-concrete section and at the lower end, where it will ultimately be under some 20 ft. of back pressure from the proposed reservoir, a reinforced-concrete section, 8 ft. in diameter, is used for 26,000 ft. A few other stretches, all short, will be under slight upward pressure, but the character of their design is not stated. The consulting engineers recommend that to make the aqueduct "watertight, strong and permanent," it should be built of 1:2:4 mixture, the coarse material to be screened gravel. To avoid transverse cracks, construction in sections not more than 20 ft. long is advised, with a ¼x3-in. steel bar or other suitable water stop between each section.

Mention has already been made of a tunnel beneath the Red River, on the metal portion of the conduit. The shafts will be about 75 ft. deep and the tunnel some

900 ft. long and 6¼ ft. in minimum diameter. The space between the pipe and the rock will be filled with concrete, with grouting under pressure where necessary. The 5-ft. cast-iron pipe used here will have a 1.9-in. shell and "a special bell about 15 in. long, so designed as to permit the joint between the pipes to be calked from the inside with lead wool."

In view of the apparent desire of the City of Winnipeg and the Greater Winnipeg Water District to interest contractors in this work at as early a date as possible, and because of the appeal the figures will make to engineers as well, we quote the cost estimates given in the report, first in grand summary, then in more detail:

ESTIMATES OF COSTS

The summary of these estimates is as follows:

85 miles of construction railway	$1,020,000
Clearing	55,000
Ditching	90,000
Telephone line	25,000
12,000 lin.ft. 4-ft. cast-iron pipe from McPhillips Street reservoirs to Victoria Park at $23.17	278,000
900 lin.ft. tunnel under Red River, including the shafts and the 5-ft. cast iron pipe laid in shafts and tunnel, at $144.44	130,000
43,200 lin.ft. 5-ft. steel pipe, extending from the easterly shaft of the Red River tunnel to the junction with the concrete aqueduct about one mile east of Transcona, at $20.74	896,000
447,300 lin.ft. concrete aqueduct, extending from the end of the steel pipe to Indian Bay, with all appurtenances, at $19.51	8,729,000
Falcon River diversion	121,000
	$11,344,000
Add for administration, engineering and contingencies, 15%	1,701,600
Total estimated cost	$13,045,600

In greater detail the estimates are as follows:

4-Foot Pipe in Winnipeg

12,000 lin.ft. 4-ft. cast-iron pipe, weighing 730 lb. per lin.ft. laid nearly all the way in the streets of Winnipeg from the McPhillips St. reservoirs to Victoria Park at $19.60 per lin.ft.	$235,200	
Replacing pavements about one-quarter of whole length of pipe	9,000	
Allowance for changing existing pipes	24,000	
Valves and special castings	10,000	
		$278,200

Red River Tunnel

900 lin.ft. of tunnel excavation, and 150 lin.ft. of shaft excavation	$60,000	
1,050 lin.ft. 5-ft. heavy cast-iron pipe of special design	30,500	
Materials and labor, putting cast-iron pipe in place	8,400	
Filling solidly the space between the pipe and the walls of the tunnel and shaft with concrete and grout	31,000	
		$129,900

5-Ft. Steel Pipe East of Red River

43,200 lin.ft. 5-ft. steel pipe, with riveted joints, made of plates ¼ of an inch in thickness and weighing 291 lb. per ft. laid in place, at $19.50 per ft.	$842,400	
30 ft. arched concrete culvert for supporting the pipe line across the Seine River	35,000	
Additional costs of railway crossings	8,000	
Replacing pavements and changing existing pipes	5,000	
Valves and special castings near the junction of this pipe with the concrete aqueduct	6,000	
		$896,400

447,330 ft. = 84.72 miles of concrete masonry aqueduct from the end of the steel pipe east of Transcona to Indian Bay, comprising the following items of work:

1,880,000 cu.yd. earth excavation west of the Summit Cut	at	$0.60,	$1,116,000
1,100,000 cu.yd. earth excavation in Summit Cut	at	0.75,	825,000
94,000 cu.yd. of rock excavation	at	2.50,	235,000
2,300,000 cu.yd. refilling and embankment	at	0.40,	920,000
340,000 cu.yd. concrete	at	13.00,	4,420,000
29,000 cu.yd. reinforced concrete	at	17.00,	493,000
13,000 ft. timber platform	at	40.00,	520,000
Steel for reinforced aqueduct			70,000
Special work at and near river crossings, including waste weirs			80,000
Gate and screen chamber and other works at intake			50,000
Total for concrete aqueduct and appurtenances			$8,729,000

In making the above estimate of the cost of the aqueduct we have assumed, for the purposes of the estimate, that the trenches where in earth will be excavated with side slopes of one horizontal to one vertical.

Ten per cent. has been added to the computed net quantities of concrete, timber platform, earth excavation west of the Summit Cut, and refilling and embankment, to cover waste and the larger quantities which are likely to result from necessary changes in design to meet conditions presented from time to time in the actual construction of work.

Estimates of Quantities and Cost of Works for the Diversion of Falcon River

Embankment 5070 ft. long, requiring the following quantities of mate

Sand and gravel for embankment including 10% for shrinkage and loss	170,000 cu.yd. at $0.45,	$7
Riprap	12,800 cu.yd. at 1.50,	
Trestle	5,000 lin.ft. at 2.00,	
Channel, 3,300 ft. long 35 ft. wide and 7 ft. deep from west end of Indian Bay to Snowshow Bay, 30,000 cu.yd. earth excavation	at 0.50,	
Total, Falcon River diversion		$12

Finally, we note that the consulting engineers estimate the yearly operating cost of the aqueduct as about $40,000. This includes the superintending engineer and general administration, but, of course, nothing for interest, sinking fund, or taxes.

Effect of Heavy Motor Traffic on Cost of Road Maintenance

The County Engineer of Middlesex County, England, H. T. Wakelam, in a recent paper read before the Institution of Municipal and County Engineers, gave some figures showing the pronounced increase in the cost of maintenance of water-bound macadam roads under his jurisdiction after a regular line of six-ton motor busses was put into service over the road. The following table gives for ten different roads the average cost of road maintenance per yard per annum for the three years previous to the initiation of the motor omnibus traffic and the same figures for the one year since the motors have been in use. The maintenance figures include only the actual repair of the road and not the watering nor cleaning thereof.

TABLE SHOWING INCREASED COST OF ROAD MAINTENANCE DUE TO HEAVY MOTOR TRAFFIC

Road	Costs in cents per sq.yd. per annum: 3 years before motor traffic	1 year after motor traffic
A	13.55	25.99
B	11.27	33.14
C	14.12	41.93
D	15.67	16.98
E	9.16	15.43
F	8.71	15.15
G	6.00	16.90
H	5.19	11.14
I	21.45	36.48
J	16.98	42.96
Average	12.33	25.60

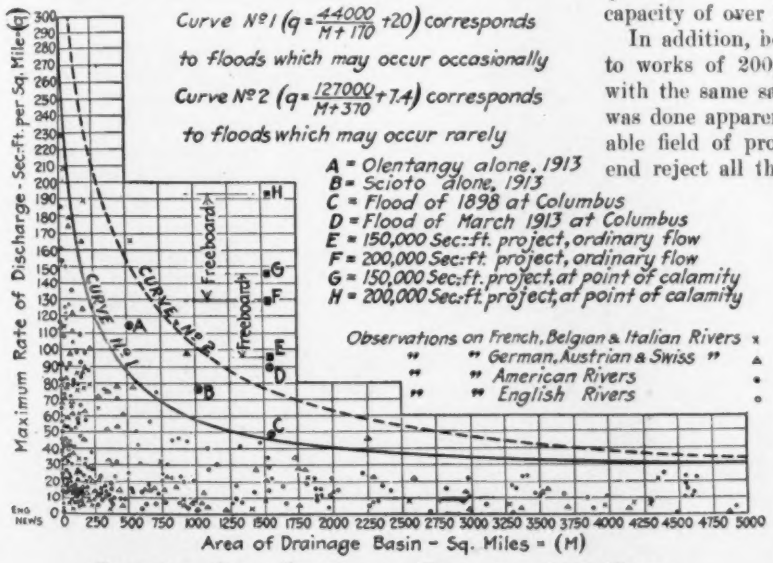
In other words, the charge for maintaining a road during 1913 (the last year noted in the above table) amounted to 1.83c. per ton per mile, whereas in 1911-12, before the omnibuses were installed, the cost per ton per mile was 1.22c. This increased road upkeep of about 0.61c. per ton per mile amounts to about 4c. per car per mile. The author of the paper remarks that these figures show that a recent bill introduced into Parliament requiring a tax on all omnibuses operating on roads of 0.75 per 'bus-mile is insufficient to care for the excess damage caused by these machines. The author recommends that the road authorities should have power to control the weight of the vehicles and, if necessary, to prohibit a *continuous* use of mechanically propelled vehicles of excessive weight over any given road.

An Oil-Burning Crematory for human remains is soon to be built by the United States government, at Ancon, in the Panama Canal Zone, according to press dispatches. It is stated that the contract includes the construction of two retorts, each equipped with burners, placed side by side. They are required to be free from smoke, noise or odor, and complete incineration must take place in two hours.

Columbus Flood-Protection; Recommendations of the Consulting Hydraulic Engineers

After the great floods of Ohio and Indiana at the end of March last, one of the first communities to plan for protective work was the city of Columbus.* The firm of Alvord & Burdick (hydraulic and sanitary engineers, Chicago) was engaged to investigate the Columbus situation and recommend means for protection. A summary of recommendations by these engineers, submitted last week, is the first real and well planned step reported from any point in the flood districts toward correcting the conditions which rendered the March flood so peculiarly disastrous.

Our accounts of the Columbus flood brought out clearly that the constricted winding channel of the Scioto, unable to take care of the water, threw the flood against the levees of the west side, where, after overtopping the levees, it could cut across the neck of the eastward bend of the river. The west side was inundated with great loss of life and much property damage. Besides this principal damage there was a great deal of trouble caused by flooding of lowlands where levees either did not exist or were inadequate. These conditions pointed to the necessity of two general lines of improvement: (1) enlarging the flood-flow capacity of the channels through the city, and (2) leveeing the lowland to a proper height and width to protect all lands except such as might more economically be left exposed to inundation by high floods.


Curve No 1 ($q = \frac{44000}{M+170} + 20$) corresponds to floods which may occur occasionally
Curve No 2 ($q = \frac{127000}{M+370} + 7.4$) corresponds to floods which may occur rarely
A = Olentangy alone, 1913
B = Scioto alone, 1913
C = Flood of 1898 at Columbus
D = Flood of March 1913 at Columbus
E = 150,000 Sec.-ft. project, ordinary flow
F = 200,000 Sec.-ft. project, ordinary flow
G = 150,000 Sec.-ft. project, at point of calamity
H = 200,000 Sec.-ft. project, at point of calamity
Observations on French, Belgian & Italian Rivers
" " German, Austrian & Swiss "
" " American Rivers
" " English Rivers
CURVE No 1
CURVE No 2
Freeboard
Freeboard
Maximum Rate of Discharge - Sec.-ft. per Sq. Mile (q)
Area of Drainage Basin - Sq. Miles = (M)
ENG NEWS

COLUMBUS FLOOD-PROTECTION BASIS AND 1913 FLOOD PLOTTED ON KUICHLING'S FLOOD-FLOW DIAGRAM

THE 1913 FLOOD

The engineers begin with a determination of the maximum flow in the 1913 flood at Columbus. They summarize their findings as follows:

> It is concluded that the maximum flow of the flood of 1913 at Columbus was, in round numbers, 140,000 cu.ft. per sec. Of this total, approximately 80,000 cu.ft. came down the Scioto, and 60,000 cu.ft. from the Olentangy River at the apex of the flood, and the average flows for 24 hr. at the flood apex were 68,000 and 51,000 in the Scioto and Olentangy, respectively, or 119,000 total.

The last figure they compare with an *average* 24-hr. flood-flow of the two rivers of 33,800 cu.ft. per sec., from which it follows that the flood of March, 1913, was three and one-half times as great as the average flood. Study of flood data generally leads them to conclude that the flood of 1913 was a *great flood*, practically unprecedented in the eastern United States, and that the rainfall which caused the flood was "one of the greatest ever known in this country east of the Pacific Coast." These guardedly stated conclusions are supplemented by the further assertion:

> Circumstances may occur to produce a greater flood hereafter, but it is not probable that such floods will greatly exceed the flood just past.

BASIS OF DESIGN OF PROTECTIVE WORKS

The 1913 flood-flow at Columbus having been 140,000 cu.ft., the engineers adopt a figure of 150,000 as the least which the flood-protection works should be designed for. In planning the works, however, they have given the channel banks and levees a clearance of 12 ft. above flood level (on the Olentangy only 6 ft.), besides ample crest width to be safe against leakage or caving; in consequence, their 150,000-ft. works really have an emergency capacity of over 200,000 cu.ft. per sec.

In addition, however, the engineers gave consideration to works of 200,000 cu.ft. per second normal capacity, with the same safety margin as in the other case. This was done apparently to give a better survey of the available field of protective work, and the engineers in the end reject all the 200,000-ft. projects as unduly expensive, and for other reasons not desirable or feasible.

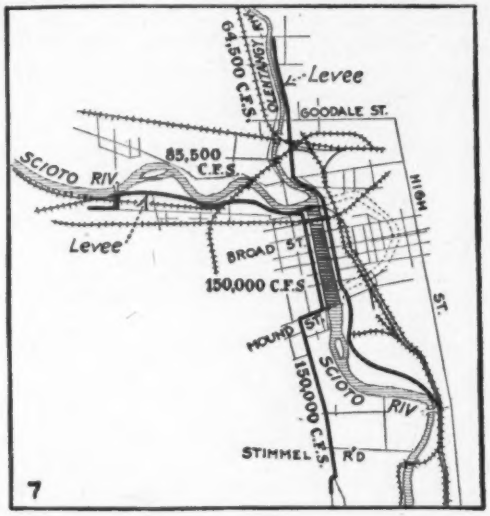
Immediately after the Columbus flood had subsided, the city engineering authorities devised and discussed among themselves two general projects for protective work. One of these centered about improvement of the existing channel, winding though it be. The other involved as its main feature a cutoff channel diagonally southeastward through the western part of the city, leading from the upper Scioto back to the combined channel below the city, so that the existing channel through the principal portion of the city would become a mere continuation of the Olentangy. The various projects which the consulting engineers have drawn up and examined, include projects quite similar to the two just mentioned, though differing in detail and more thoroughly worked out. However, the project which they favor differs from either one, and involves a river diversion or cutoff intermediate between the extreme westerly cutoff and the present river channel, and so located as to take care of the Olentangy and upper Scioto combined.

THE PROJECTS STUDIED

The report includes, in all, ten projects which were drawn up and studied. The first six are for a normal capacity of 200,000 cu.ft. per sec.; only one of these in-

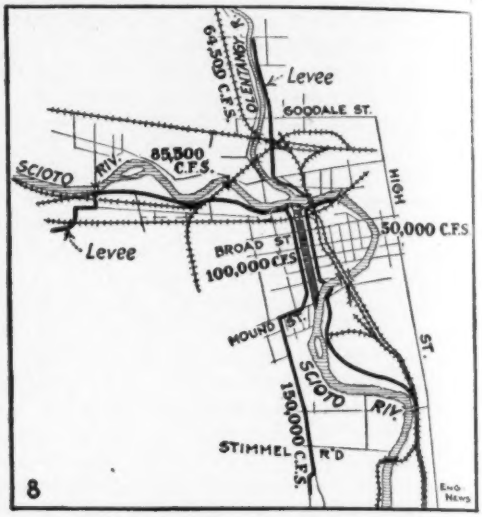
*For an account of the Columbus flood and how it was handled, see "Engineering News" of Apr. 10, 1913, pp. 744-748, "The Recent Flood at Columbus, Ohio," by Julian Griggs.

volves storage or detaining reservoirs in the headwaters of the stream, while the other five employ only channel correction, bypassing, or diversion, in the city, and channel improvements just above and just below. Four projects are for 150,000 cu.ft. per sec. Of these, two were



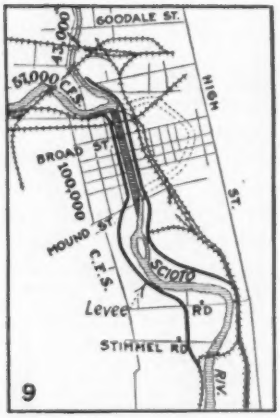
MAY-STREET DIVERSION (PROJECT 7) WITHOUT RESERVOIRS

As already mentioned, the engineers themselves reject the six 200,000-ft. projects as being expensive and unnecessarily ample. We have, however, shown one of these projects, that for a river diversion along May St., so that it may be compared with one of the 150,000-ft. projects,

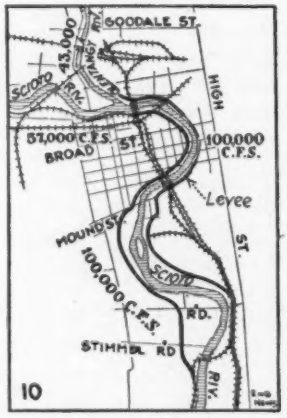


MAY-STEET BYPASS (PROJECT 8)

(Practically the same improvement will provide for 200,000-c.f.s. floods if headwater reservoirs are added; project 6.)



HEADWATER RESERVOIRS AND RIVER DIVISION (PROJECT 9) WITH RESERVOIRS



HEADWATER RESERVOIRS AND CHANNEL CORRECTION (PROJECT 10)

COLUMBUS FLOOD PROTECTION: FOUR PROJECTS FOR 150,000-C.F.S. FLOODS

planned with reservoirs, so that out of the ten projects, three are combination and seven are river improvement alone.

Sites for storage reservoirs in the headwaters of the Scioto and the Olentangy were located, one on the Scioto above Dublin and two on the Olentangy (only one of the two to be used) at Flint and farther upstream at Delaware. Proper control of these reservoirs, it is estimated, should secure a reduction of maximum flood-flow by 50,000 cu.ft. per sec. The cost of constructing these reservoirs would be about $3,500,000, as against $10,000,000 to $23,000,000 for the river correction and bypass work in the city.

and an idea obtained of the difference in extent of work.

Of the 150,000-ft. projects, the engineers favor those without reservoirs as being slightly cheaper; but inasmuch as the reservoirs also protect certain districts above and below Columbus, a combination project may be more advantageous when considered broadly, and should be adopted in case financial coöperation between Columbus and other communities can be secured.

Below is given in tabular form a summary of the estimated costs of the ten different projects, showing that the costs range from about $10,000,000 to about $23,000,000.

Columbus Flood-Protection Projects

Capacity 200,000 cu.ft. per sec.

Project	Short Description	Cost
1	*Channel Improvement* around bend. Minor bypasses in upper Scioto and Olentangy. Width at bend of river will be about 1000 ft.	$23,382,300
2	*Channel Improvement and May St. Bypass.* Upper sections treated as in (1). The improved channel is to take 100,000 c.f.s. and the bypass 150,000 c.f.s.	$22,440,800
3	*Channel Improvement and Asylum Bypass.* Bypass at west edge of West Side, 100,000 c.f.s.	$21,063,900
4	*May St. Diversion.* Old channel at bend abandoned; improvements above and below similar to those in the other projects of equal capacity	$15,483,700
5	*Unimproved Channel and May St. Bypass.* The existing channel takes 50,000 c.f.s., the bypass to take 150,000	$15,275,600
6	*Reservoirs, Bypass and Existing Channel.* Reservoirs reduce flow	

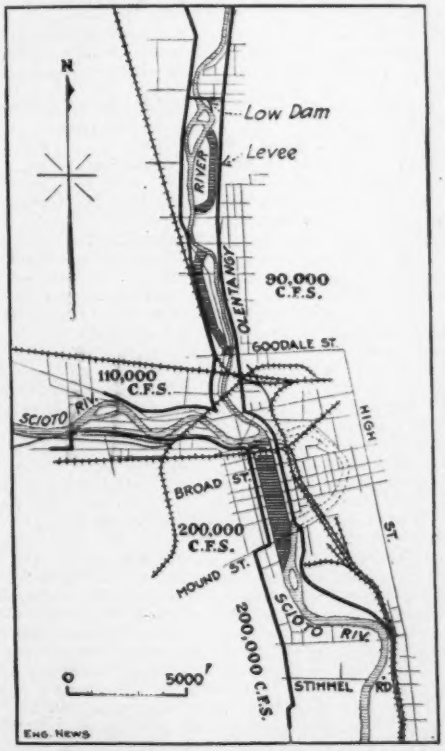
50,000 c.f.s., existing channel takes 50,000, May St. bypass to take 100,000 ..... $13,616,900
Capacity 150,000 Cu.Ft. per Sec.

7 *May St. Diversion.* Old channel at bend abandoned. Levees, etc., above and below city, are much less extensive than for projects of larger capacity. West bottoms of Olentangy not leveed $11,263,300

8 *Unimproved Channel and May St. Bypass.* The existing channel takes 50,000 c.f.s., the bypass to take 100,000 ..... $10,120,600

9 *Reservoirs and May St. Diversion.* Old channel at bend abandoned. Reservoirs reduce flow 50,000 c.f.s., diversion to take 100,000 ..... $11,308,000

10 *Reservoirs and Channel Improvement.* The existing channel around the bend to be improved for 100,000 c.f.s. flow $11,259,700



COLUMBUS FLOOD PROTECTION: MAY-ST. BYPASS PROJECT FOR 200,000 C.F.S. CAPACITY

(Project 4; may be compared directly with Project 8.)

The engineers state their conclusion that

No practicable measure of flood relief can be had at much less cost than the lowest figure mentioned, and no greater sum could profitably be spent at this time than the higher sum mentioned.

As giving some idea of the justifiability of such expenditure, the engineers state that, disregarding lives lost and suffering caused, they find the damage done by the 1913 flood at Columbus to have been about $5,600,000, exclusive of depreciation of values; that the present value of the district flooded in March, 1913, at Columbus, is about $50,000,000; that the annual flood damage at Columbus for the past 15 years is about $520,000. Thus they conclude that the financial considerations alone are sufficient to warrant undertaking the protective work, at least the cheaper of the projects studied.

Of the two 150,000-ft. projects without reservoirs (Nos. 7 and 8), the engineers recommend No. 7 as preferable, because, while costing somewhat more than No. 8, it creates more favorable conditions for the development of the city. This recommendation, however, is made contingent on the cession of the riparian owners' rights on the existing river channel (to be abandoned under Project 7).

A feature of these flood-protection projects as designed is that at most points their highest flood level is considerably below (5 to 14 ft. below) that of the 1913 flood. As already stated, however, the levees are planned to be carried to a height of 12 ft. above flood level along the Scioto, and 6 ft. along the Olentangy, and the bank-full capacity of the improvement as projected would be one-third to one-half more than the nominal capacity.

Convention of the National Paving Brick Manufacturers' Association

The tenth annual meeting of the National Paving Brick Manufacturers' Association, held in Cleveland, Ohio, Sept. 17 and 18, was notable in a number of ways. In the first place it was the second "annual" meeting held in 1913. By an amendment to the constitution, these meetings are now held in September instead of March in order that, if found advisable, part of the convention time may be given up to showing invited guests the manufacture or use of vitrified paving brick. The meeting was unique, as an engineering conference, in that fully two-thirds of those in attendance (over 300) were guests—engineers, road commissioners, etc., invited to inspect the city and country pavements of Cleveland and Cuyahoga County, where many miles of brick roads were seen. The meeting, finally, was remarkable for the brevity of formal session program. Besides some routine business, such as elections and business reports, there were only three formal papers, the rest of the two days being devoted to inspections—and a banquet.

The report of the President, C. J. Deckman, of Cleveland, dealt with association activities largely, commenting on the present prosperity of the industry, advising a policy (previously recommended to the companies) of refusing to supply brick on work not covered by approved specifications for laying (the association has adopted specifications of recommended practice with portland-cement-grout filler for brick on concrete, crushed stone and earth bases). He recommended the organization of an engineering inspection force which should coöperate with municipal or county authorities in seeing that approved construction is secured wherever paving brick is being used. He also advised that production costs be studied among the companies, though prices should not be taken from a free competitive basis.

The report of the Secretary, W. P. Blair, of Cleveland, also discussed association and industry developments in the six months since the last annual meeting. He called attention to the completion of the Chevy Chase (Maryland) experimental brick road by the U. S. Office of Public Roads, and the proposed reconstruction of the

"National Road" eastward from Columbus, Ohio. He reported also that, instead of brick pavement being universally used in the best manner possible, there was a growing tendency to use inadequate foundation, cushion and filler, a situation which had to be corrected by constant effort in teaching how best to use brick. Specifications for the inspection and testing of paving brick were presented as recommended by a sub-committee of the American Society for Testing Materials. No action was taken by the Association, and none will be before the report is adopted or rejected by the Society.

The report of the assistant secretary, H. H. MacDonald, of Cleveland, dealt with the publicity work of the Association, particularly in securing new members. The officers mentioned above were reëlected.

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Vanadium Steel in Locomotive Construction*

By Geo. L. Norris†

In 1908, when several of the leading railways specified vanadium-steel parts for test purposes, only 53 locomotives were so equipped, or 2% of the total number built that year. Awaiting the outcome of these tests, but little vanadium steel was specified during 1909, but evidence of the success of these tests is shown by the marked increase in the specification of vanadium steel for locomotives built in 1910. From 1910 the use of vanadium steel in locomotive construction has been steadily increasing, and in 1912 over 25% of the locomotives built weighing over 200,000 lb. had vanadium-steel parts.

The earliest application was for cast-steel locomotive frames. A number of vanadium-steel frames were put into service early in 1907 and all of them are still in service without having failed. There are now over 5000 vanadium cast-steel frames in service, and for heavy locomotives they are rapidly becoming standard. Failures of vanadium frames have been insignificant, less than 0.5% from all causes. If we eliminate failures due to an especially weak point in design, from wrecks or failure of other parts, the percentage is less than 0.1%.

An investigation made a few years ago showed that frame failures constituted at least 20% of the cost of locomotive maintenance. The use of vanadium-steel frames, therefore, means a very substantial lowering in maintenance cost.

While the principal application of vanadium cast steel has been for frames, it is being used to advantage for other castings, as, in addition to its high elastic limit and dynamic strength, it has a much higher wear-resisting quality than ordinary cast steel. In breaking up scrap frames with an 8000-lb. drop ball, eight or nine blows are not unusual for the vanadium frames, while carbon frames usually require only one or two blows to break them.

Vanadium-steel castings differ in composition from ordinary steel castings only by the presence of 0.16 to 0.25% of vanadium. The addition of this amount of vanadium increases the elastic limit 30 to 40% above that of the same steel without vanadium, in the annealed condition, and without decreasing the ductility as determined by elongation and reduction of area. In general the ductility is considerably increased as well. The dynamic strength, or resistance to repeated stresses, is very much increased, generally 50% or more.

Coming to vanadium-alloy forging and machinery steels, chrome-vanadium steel is now being extensively used for such parts as tires, rolled wheels, axles, connecting rods, crankpins, piston rods, springs, air-brake pump tappet rods, valve motion, and various other parts subjected to repeated stresses and great wear. It responds perfectly to heat-treatment, giving a high elastic limit combined with hardness and great toughness and superior wear-resisting qualities.

Tires and wheels form probably one of the largest single items of maintenance cost of locomotives, and the cost is constantly growing with the rapidly decreasing mileage due to increased loads and harder service. From the time that the weldless steel tire was invented by Krupp, in 1853, the composition of the steel used has remained practically the same. With the marked increase of weight and power of locomotive equipment that has taken place during the last ten or twelve years, the tire mileage has rapidly decreased. It is evident that there is need of an improvement in the quality of the tires, not only to obtain better mileage under present conditions but to successfully meet the more severe conditions of the near future.

The only way to improve the quality of the steel now in general use is by heat-treatment of the tires. However, this kind of steel is not especially suited to heat-treatment, and only relatively small increases in physical properties can be obtained by this means, without increasing the danger of the tire breaking through brittleness. During the past year there have been made and put into service about 1000 heat-treated chrome-vanadium tires to specifications calling for an elastic limit 75 to 100% greater than obtained in ordinary carbon tires and about 50% greater than for heat-treated carbon tires.

The specifications call for a falling-weight test as well as tensile test. In one of these tests 35 blows of a 2240-lb. tup were given, without breaking the tire. Three blows each from 10 ft. and 15 ft.; 4 blows from 20 ft.; 9 blows from 25 ft.; and 16 blows from 30 ft., the maximum height of the drop-testing machine. The test piece cut from the tire showed the following properties; elastic limit, 122,000 lb.; tensile strength, 158,430 lb.; elongation in 2 in., 50%; reduction of area, 41%.

Steel-tired tender and coach wheels and rolled-steel wheels come in the same category as the locomotive driving-wheel tires so far as fast wear is concerned. In addition, they are liable to give considerably less mileage per ½-in. due to danger of shelling or flaking on the tread, which necessitates considerable loss in metal to remove these defects.

The use of chrome-vanadium steel will doubtless reduce the liability to shell to very great extent, judging from the micro-structure and physical properties of the vanadium steel. This opinion is apparently confirmed by the records of tender wheels on two roads that have had considerable trouble from shelly treads. None of these steel-tired wheels have been reported as shelling.

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The design and construction are under the direction of the Department of Public Works of Canada, Eugene D. Lafleur, Chief Engineer, and E. A. Hoare, of Quebec, has been appointed to supervise the execution of the work.

The Levis dock will be when completed the largest dry dock in the world, slightly larger than the present design of the new dry dock under consideration for the port of Boston. This latter dock is not now intended to be quite as large as stated in the note in our issue of Aug. 28, 1913, p. 435, but will be of the size noted in the following table showing the three largest dry docks, one completed, one under construction and one under design:

Location	Clear length	Width	Max. depth	Date
Levis, Que.....	1150	120	45	Under construction
Boston, Mass.....	1150	120	35	Under design
Gladstone Dock, Liverpool, Eng...	1020	120	46	1913

The Influence of Vibration on Magnetic Properties was investigated by E. Gumlich and W. Steinhaus in the Physikalisch-Technishe Reichsanstalt (Berlin). They conclude from tests that oft-repeated jarring or vibration such as occurs during railway transportation lowers the magnetic qualities of annealed dynamo core sheets by reducing the permeability and increasing the hysteresis loss. The tests on which this conclusion is found ("Stahl und Eisen") were made on small samples of sheet steel shaken in a specially arranged tumbler for subjecting them to shock and vibration.

A Head Collision on the Long Island R.R. occurred between two electric all-steel trains, Sept. 22, in a 20-ft. cut on a sharp curve, under a bridge at College Point, Long Island, N. Y. A train bound for Whitestone Landing, N. Y., made up of two cars containing but few passengers, was 10 min. late and running at about 10 mi. per hr., not having gotten up to speed since its stop at College Point. Another train, consisting of five cars containing several hundred passengers bound for New York was 20 min. late and traveling at about 40 mi. per hr. In the collision both motormen were killed as was also a conductor of the railroad who was on his way to New York to report for duty. Five passengers were sent to hospitals while 49 others sustained minor injuries which were treated at the scene of the wreck. Oonly three of the cars were damaged, the two head cars and the second of the train for New York.

The wreck, in the opinion of Coroner Ambler, College Point, and J. A. McCrea, General Manager, Long Island R.R., according to press dispatches, was due to disregard by the signalman in the Whitestone Junction signal tower, of Rule 5 of the railroad, which orders that "at the end of double

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A New Dry Dock of Record Size is to be built by the Canadian government on the St. Lawrence River, near Levis, Quebec, across the river from the city of Quebec. The dry dock will have the following dimensions: length from caisson stop to head wall, 1150 ft.; width of entrance, 120 ft.; depth on sill at ordinary high water, 40 ft. It will be divided in two parts, 650 and 500 ft. respectively, the outer entrance will be closed by a steel rolling caisson, and a floating caisson will close the inner entrance. The dock will be emptied by three electrically driven centrifugal pumps, each having a capacity of 60,000 gal. per min., the current being furnished by three turbo-generators.

The design and construction are under the direction of the Department of Public Works of Canada, Eugene D. Lafleur, Chief Engineer, and E. A. Hoare, of Quebec, has been appointed to supervise the execution of the work.

The Levis dock will be when completed the largest dry dock in the world, slightly larger than the present design of the new dry dock under consideration for the port of Boston. This latter dock is not now intended to be quite as large as stated in the note in our issue of Aug. 28, 1913, p. 435, but will be of the size noted in the following table showing the three largest dry docks, one completed, one under construction and one under design:

Location	Clear length	Width	Max. depth	Date
Levis, Que.....	1150	120	45	Under construction
Boston, Mass.....	1150	120	35	Under design
Gladstone Dock, Liverpool, Eng...	1020	120	46	1913

The Influence of Vibration on Magnetic Properties was investigated by E. Gumlich and W. Steinhaus in the Physikalisch-Technishe Reichsanstalt (Berlin). They conclude from tests that oft-repeated jarring or vibration such as occurs during railway transportation lowers the magnetic qualities of annealed dynamo core sheets by reducing the permeability and increasing the hysteresis loss. The tests on which this conclusion is found ("Stahl und Eisen") were made on small samples of sheet steel shaken in a specially arranged tumbler for subjecting them to shock and vibration.

A Head Collision on the Long Island R.R. occurred between two electric all-steel trains, Sept. 22, in a 20-ft. cut on a sharp curve, under a bridge at College Point, Long Island, N. Y. A train bound for Whitestone Landing, N. Y., made up of two cars containing but few passengers, was 10 min. late and running at about 10 mi. per hr., not having gotten up to speed since its stop at College Point. Another train, consisting of five cars containing several hundred passengers bound for New York was 20 min. late and traveling at about 40 mi. per hr. In the collision both motormen were killed as was also a conductor of the railroad who was on his way to New York to report for duty. Five passengers were sent to hospitals while 49 others sustained minor injuries which were treated at the scene of the wreck. Oonly three of the cars were damaged, the two head cars and the second of the train for New York.

The wreck, in the opinion of Coroner Ambler, College Point, and J. A. McCrea, General Manager, Long Island R.R., according to press dispatches, was due to disregard by the signalman in the Whitestone Junction signal tower, of Rule 5 of the railroad, which orders that "at the end of double

tracks when signalmen are on duty, signals will not be given to trains to enter single tracks until all superior overdue trains have arrived or orders have been given permitting inferior trains to proceed." Superior trains, between midnight and noon on the Long Island R.R., are considered to be all those bound for New York. Hence, according to the railroad officials, the towerman should have held up the inferior (Whitestone Landing) train until the other had passed his tower and onto the main line. Instead, he allowed the former to enter the single track before the superior train had left it.

PERSONALS

Mr. R. W. Powrie has been appointed district engineer of the Chicago, Milwaukee & St. Paul Ry., at Minneapolis, succeeding Mr. M. D. Rhame.

Mr. Howard S. Reed, Assoc. M. Am. Soc. C. E., for the past eight years connected with the United States Reclamation Service, has resigned his position.

Mr. Alfredo C. R. Janni, who for some time has been connected with the Bridge Department of the city of St. Louis, has removed to New York City and has opened there an office as Consulting Engineer.

Mr. Wiley F. Corl, M. Am. Soc. E. E., formerly Electrical Engineer, Arnold Co., Chicago, will have charge of the new electrical department of Allen & Garcia, Consulting and Constructing Engineers, Chicago.

Mr. W. H. Fisher, for the past four years connected with the engineering department of the city of Spokane, Wash., has resigned his position to devote his services to the Graff Construction Co., Seattle, Wash.

Mr. John P. Hogan, Assoc. Am. Soc. C. E., formerly Engineer in charge of the Esopus division of the Catskill aqueduct, has been transferred to New York City where he will direct the work on the reservoir and conduit division of the city aqueduct department, Board of Water Supply.

Mr. T. R. Agg, Road Engineer for the Illinois Highway Comission, was recently elected Assistant Professor of Civil Engineering, Iowa State College, in charge of highway engineering. Mr. Agg also will be connected with the work in Road Experimentation for which an annual appropriation of $10,000 by the state is available.

Mr. Chester L. French, formerly Superintendent of the Connellsville division of the Baltimore & Ohio R.R., has been promoted to be Assistant General Superintendent of the Pittsburgh division. Mr. L. O. Eaton formerly Assistant Superintendent of the Connellsville division, will succeed Mr. French, as Superintendent of the latter division.

Mr. Wm. H. Foster, until recently Superintendent of the Old Colony division, New York, New Haven & Hartford R.R., has been appointed, to take effect Sept. 15, Superintendent of the Shore Line division of the same railroad. Mr. Henry C. Oviatt, formerly Assistant Mechanical Engineer, is appointed Superintendent of the Old Colony division, succeeding Mr. Foster.

Mr. Charles H. Motsett, Freight Trainmaster, New York, New Haven & Hartford R.R., has been appointed Superintendent of the New York Division, with offices at Harlem River, New York City. Mr. Motsett began railroad work in 1891 as yard clerk for the Rock Island Lines. He served as trainmaster of the Minneapolis & St. Louis R.R. 1905-8, when he was appointed Freight Trainmaster for the New Haven, at Harlem River.

Mr. Everett E. Stone, M. Am. Soc. C. E., former Mayor of Springfield, Mass., was nominated by Governor Foss, on Sept. 17, and the nomination confirmed by the Executive Council, as a member of the Public Service Commission of Massachusetts, succeeding Mr. George P. Lawrence, resigned. Mr. Stone was for a number of years connected with the engineering department of the Boston & Albany R.R. His present appointment is for three years.

Messrs. Arthur H. Blanchard, M. Am. Soc. C. E., Consulting Highway Engineer and Professor in charge of the Graduate Course in Highway Engineering, Columbia University, New York City, and Prevost Hubbard, Consulting Chemist, in charge of the Division of Roads and Pavements, Institute of Industrial Research of Washington, D. C., and Lecturer in Highway Engineering Chemistry, Columbia University, have formed a partnership under the firm name of Blanchard & Hubbard, Highway Efficiency Experts, New York City. At present Messrs. Blanchard and Hubbard are retained on the Advisory Highway Board for the New York State Department of Efficiency and Economy.

OBITUARY

Seth Collins Adams, an electrical engineer, connected with the Westinghouse Electric & Manufacturing Co., at New York City, died at his home in Rochelle Park, New Rochelle, N. Y. Mr. Adams was born in 1866 and was a graduate of Hamilton College.

David E. Whitford, who served in the department of the State Engineer and Surveyor, of New York, from 1852 until a few months ago, died at his home in Syracuse, N. Y., Sept. 12. Mr. Whitford was born in Saratoga County, N. Y., Nov. 30, 1829. In the State Engineer's department he rose from chainman to division engineer.

Colonel James Ross, M. Am. Soc. C. E., M. Can. Soc. C. E., financier and railroad builder, died at Montreal, Que., Sept. 20, of heart trouble, after an illness lasting two weeks. Col. Ross was born in Scotland in 1848, came to the United States at the age of 20 years, where he was early identified with the Wisconsin Central R.R. He later went to Canada to become chief engineer and later, general manager, of the Victoria R.R. In 1873 he built the Credit Valley Ry. Colonel Ross commenced the construction of the Canadian Pacific Ry. west of Winnipeg, when he was 35 years of age. Two years later the line was completed over the Rocky Mountains. During the past 20 years he was interested principally in traction, power and mining operations. At the time of his death he was President of the Dominion Coal Co., reorganized by himself, which is identified with the coal industry of Nova Scotia.

ENGINEERING SOCIETIES

COMING MEETINGS

INTERNATIONAL CONGRESS OF REFRIGERATION.
Sept. 17-Oct. 1. Third congress, at Chicago, Ill. Secy., J. F. Nickerson, Chicago.

AMERICAN ROAD CONGRESS.
Sept. 29-Oct. 4. Annual convention at Detroit, Mich. Gen. Secy., J. E. Pennybacker, Colorado Bldg., Washington, D. C.

AMERICAN SOCIETY OF MUNICIPAL IMPROVEMENTS.
Oct. 7-10. Annual convention at Wilmington, Del. Secy., Geo. H. McGovern, Chamber of Commerce, Wilmington, Del.

NATIONAL FIRE PROTECTION ASSOCIATION.
Oct. 13-18. Conference at Philadelphia, Penn. Secy., Franklin H. Wentworth, 87 Milk St., Boston, Mass.

RAILWAY SIGNAL ASSOCIATION.
Oct. 14-16. Annual meeting at Nashville, Tenn. Secy., C. C. Rosenberg, Times Building, Bethlehem, Penn.

AMERICAN ELECTRIC RAILWAY ASSOCIATION.
Oct. 13-17. Annual convention at Atlantic City, N. J. Secy., H. C. Donecker, 29 West 39th St., New York City.

AMERICAN GAS INSTITUTE.
Oct. 15-17. Annual meeting at Richmond, Va. Secy., Geo. G. Ramsdell, 29 West 39th St., New York City.

NATIONAL SOCIETY FOR PROMOTION OF INDUSTRIAL EDUCATION.
Oct. 19-25. Annual convention at Grand Rapids, Mich. Secy., C. A. Prosser, 105 E. 22d St., New York City.

AMERICAN MINING CONGRESS.
Oct. 20-25. Annual convention at Philadelphia, Penn. Secy., J. Callbreath, Majestic Building, Denver, Colo.

AMERICAN RAILWAY BRIDGE AND BUILDING ASSOCIATION.
Oct. 21-23. Annual convention at Montreal, Que. Secy., C. A. Lichty, 319 North Waller Ave., Chicago, Ill.

NATIONAL ASSOCIATION OF RAILWAY COMMISSIONERS.
Oct. 28. Annual Convention at Washington, D. C. Secy., Wm. H. Connolly, Interstate Commerce Commission, Washington, D. C.

American Petroleum Society—The society was organized, Sept. 10, at the Experiment Station, United States Bureau of Mines, Pittsburgh, Penn., and is the result of a seven-years' effort on the part of the bureau to bring together those interested in the petroleum industry. The principal officers are: President, C. D. Chamberlin; National Petroleum Association, Cleveland, Ohio; Secretary, Dr. Irving C. Allen, U. S. Bureau of Mines, Pittsburgh, Penn.

National Founders' Association—The next convention will be held at the Hotel Astor, New York City, Nov. 19-20. The secretary is J. M. Taylor, 29 So. La Salle St., Chicago, Ill.

American Association for the Advancement of Science—The next meeting will be held in Atlanta, Ga., Dec. 29-Jan 3, 1914, under the presidency of Dr. Edmund B. Wilson, Columbia University, New York City. The general secretary is L. O. Howard, Smithsonian Institution, Washington, D. C.